POWER PLANT ENGINEERING

Established Over 29 Years

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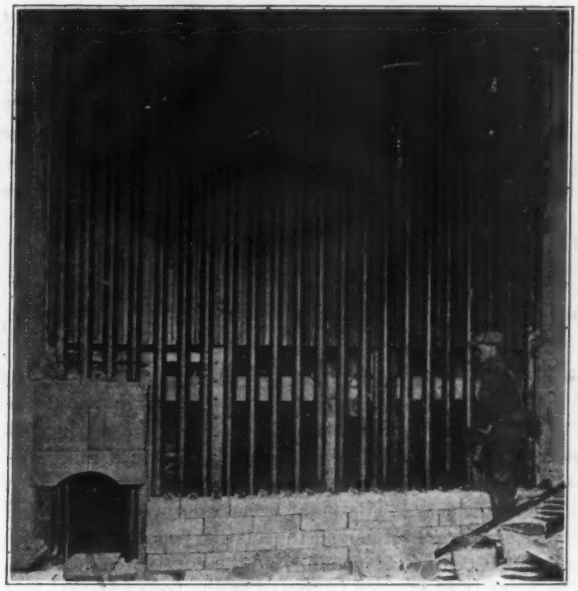
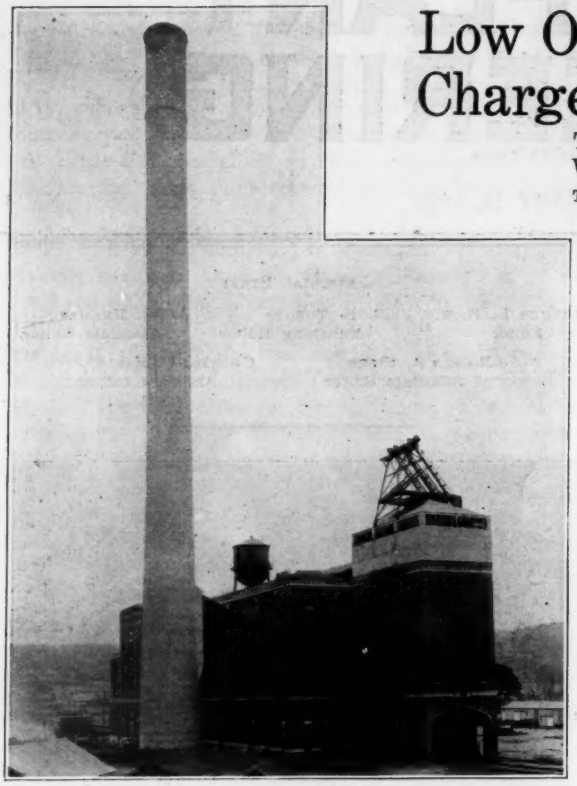


Less Confetti Used in Furnaces

WE REFER, of course, to one type of "Irish Confetti," more elegantly called fire brick or refractory material, that has been for so many years the only substance that could be used to line the inside of a furnace. The development of high capacity water-tube boilers and improved stokers, however, to say nothing of the increasing use of pulverized fuel, has led engineers to experiment with new types of furnace linings that would be less troublesome to maintain than fire brick.

Each large unit of a modern boiler plant constitutes a greater proportion of the total capacity than formerly, so that taking a boiler out of service for furnace repairs becomes a costly matter.

By returning to the fundamental principle of surrounding the combustion chamber with water that is part of the circulation of the boiler, as is done in some types of fire-tube boilers, combustion engineers have produced the water-cooled wall. This wall consists of fin tubes, as shown in the picture above, suitably connected to the mud drum and steam drum. They received one of their first tests at Hell Gate, with decidedly satisfactory results, as told on page 227 of this issue.



Low Operating Costs and Fixed Charges at Pine Grove Station

THIS PLANT IS SERVED BY A COOLING POND WHICH MAY ULTIMATELY BE ENLARGED TO SERVE 200,000 KW. BY G. G. HOLLINS

ONE OF THE decided advantages of the Pine Grove Station is that of cheap coal and the station was therefore designed to obtain simplicity and low operating cost with minimum fixed charges rather than for extremely high thermal efficiency. The plant is not equipped with economizers or air preheaters and the auxiliary motor drives have been made, as far as possible, of the constant speed type. The plant is so situated in regard to the power market that a possible large extension might be desirable in the future, therefore, while the initial installation is only 25,000 kw. the plans were made on the assumption that the station might ultimately be increased to 200,000 kw.

By far the greater part of the territory served by the East Penn Electric Co. is in the anthracite coal region where water for cooling the condensers is scarce and of poor quality on account of contamination from the mines and washeries. When it became necessary to build the new station the matter of circulating water was the determining factor in selecting the location. The plant was located at Pine Grove, Schuylkill County, just outside the coal fields and on the east branch of the Swatara Creek, which has its drainage area entirely outside the coal region. The plant is only a few miles from the coal mines from which coal can be shipped at the minimum freight rate. The stream on which the plant is located is too small to supply the full amount of water for the condensers and accordingly a spray pond was included in the installation, together with a storage reservoir for regulating the stream.

This spray pond has an area of 124,500 sq. ft. and when completed was one of the largest in the country. The initial installation of the station is 25,000 kw.; but in order to provide for growth, the capacity of the regulating reservoir was made sufficient for 75,000 kw. The local conditions will permit the future enlargement of the reservoir to provide for an increase up to 200,000 kw. in the capacity of the plant.

STREAM PASSES THROUGH THE SPRAY POND

For the present capacity of the plant the stream has at times sufficient water to supply the condensers without using the spray system. The spray pond is placed so that the stream passes through it and the excess goes over a spillway on the downstream side. The discharge from the circulating pumps is provided with motor operated valves controlled from the power house so that the circulating water from any or all of the four circulating pumps may be diverted from the sprays and discharged into the pond in front of the spillway. This arrangement permits any combination of spraying, recirculating and direct circulation that weather conditions and flow of the stream make it advisable in order to secure the maximum effective vacuum and minimum power consumption of the circulating pumps.

At the same time this arrangement does not require close attention on the part of the operator to insure that the circulating pumps are receiving the full quantity of water and that the flow of the stream is completely utilized. During the first winter of operation the sprays were seldom used and the station at times carried loads as high

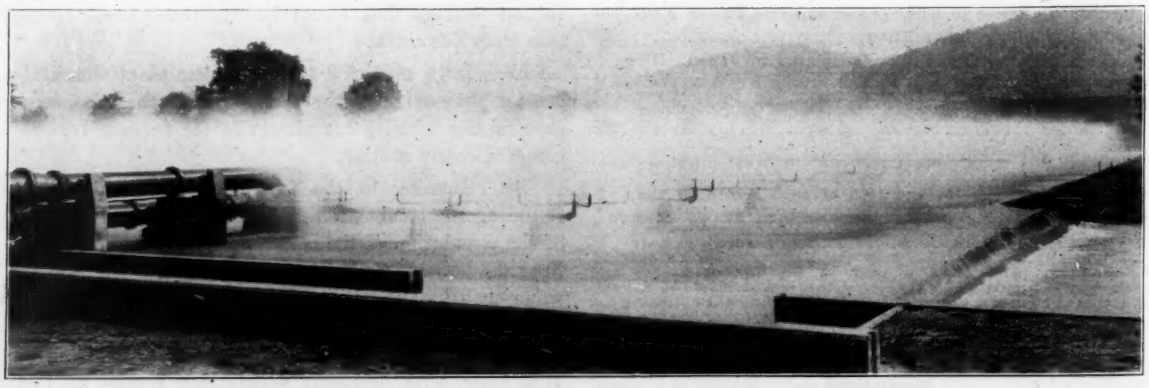


FIG. 1. THIS SPRAY POND HAS AN AREA OF 124,500 SQ. FT.

FIG. 2. ENCLOSED, SPRAY TYPE COOLERS ARE USED ON THE GENERATORS

FIG. 4. BOILERS AND STOKERS WERE INSTALLED TO DEVELOP 300 PER CENT OF RATING

as 27,000 kw. On the hottest day last summer, the air temperature at the station arose to 95 deg. F. and the maximum hourly load on the station was 17,100 kw. with a vacuum on the condensers of 27.87 in. of mercury.

Skip Hoists Installed in Duplicate

Coal burned at this station is No. 3 buckwheat anthracite which is received from the railroad cars into a double track hopper supplying two skip hoists. The skip hoists elevate the coal to a 1000-T. bunker at the end of the boiler room whence it is distributed to the stoker hoppers by either of two weigh larries. Each skip hoist has sufficient capacity to supply the plant, one hoist being merely a spare. The coal tracks extend under the boiler room for convenience in handling the cars and also to provide a place for thawing carloads of coal in cold weather. This space can be closed by rolling doors at the entrance and heating coils and also steam lance connections are provided, for thawing purposes.

For yard storage of coal a drag scraper is used and an area is provided for storing 60,000 T. This storage may be doubled by installing more back posts for the drag scraper. The coal is first unloaded into a track hopper and transferred to the operating area of the drag scraper by an inclined flight conveyor. It is reclaimed from storage by moving it with the drag scraper to the edge of the railroad siding where it is transferred to cars with a locomotive crane. Switching of coal cars and ash cars is done with a storage battery standard gage locomotive, the locomotive crane being at the present time a secondary means of moving cars in case of failure of the storage battery locomotive.

Ash is removed from the hoppers beneath the boilers by

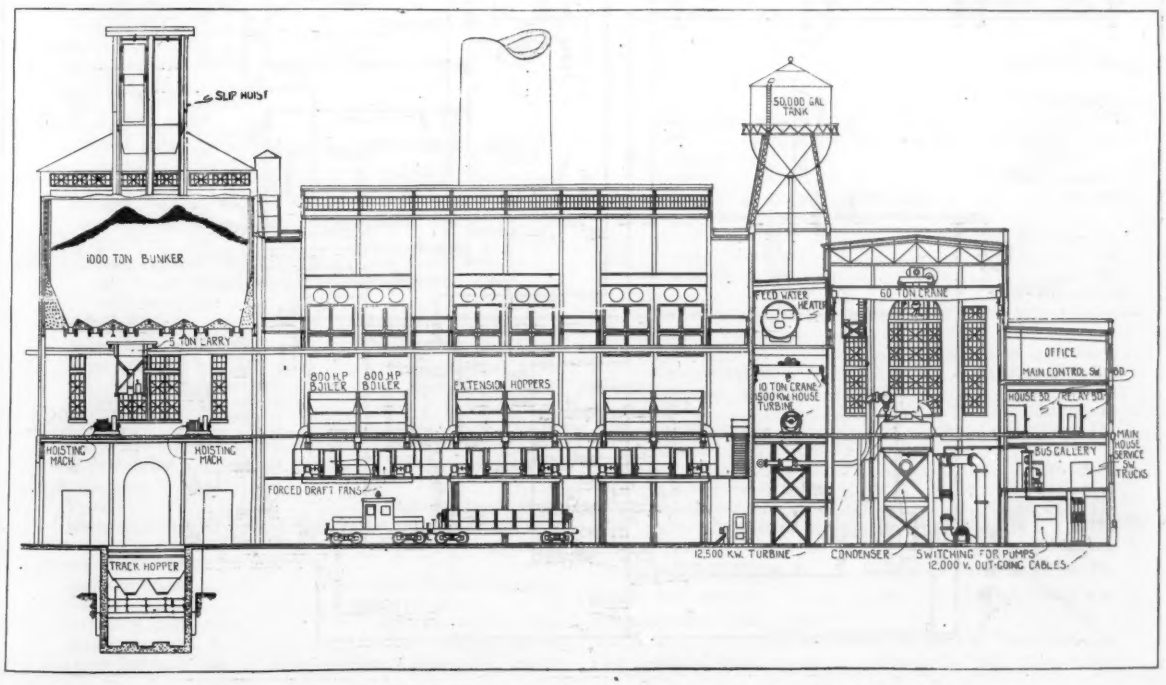


FIG. 3. COAL HANDLING PLANT IS LOCATED AT ONE END OF THE BOILER ROOM

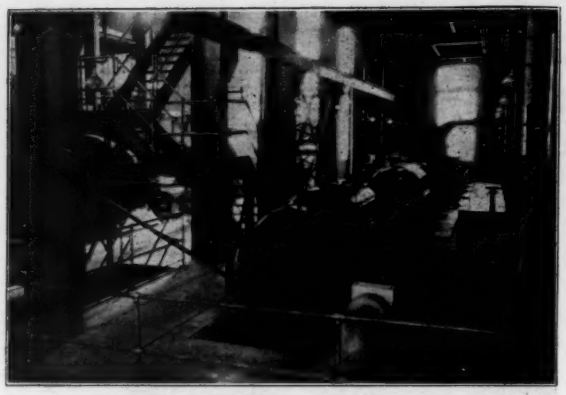


FIG. 5.* HOUSE TURBINES ARE CONNECTED TO THE MAIN BUS BARS THROUGH TRANSFORMERS

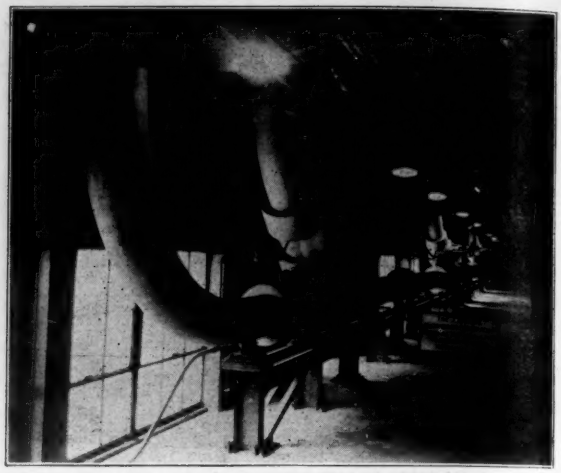


FIG. 7. STEAM HEADER ON BLOWER FLOOR BACK OF ASH HOPPERS

dumping it directly into a standard gage, air operated side dump car on the tracks underneath the boilers. There is space on the property to dispose of ash for a considerable number of years.

Boiler space is arranged on opposite sides of a central firing aisle which is at right angles to the turbine room, however, for the present installation the boilers are installed only on one side of the firing aisle. The overhead coal bunker is at the end of the boiler house which permits a skylight over the firing aisle making a light and well-ventilated boiler room. The forced draft fans are below the firing aisle and there is one for each boiler, discharging into a common air duct. The fans are driven by constant speed motors and the number of fans in service is varied to suit the load conditions. The constant speed drive was chosen after a study of the comparative power requirements of the variable speed drive and the constant speed drive, the latter being selected as it is much simpler in operation and requires just a little more power.

Boilers in this station are designed for 300 lb. pressure and 225 deg. F. superheat. The combination of stoker and boiler was designed for 300 per cent of rating as a maximum. On numerous occasions the boilers have been operated

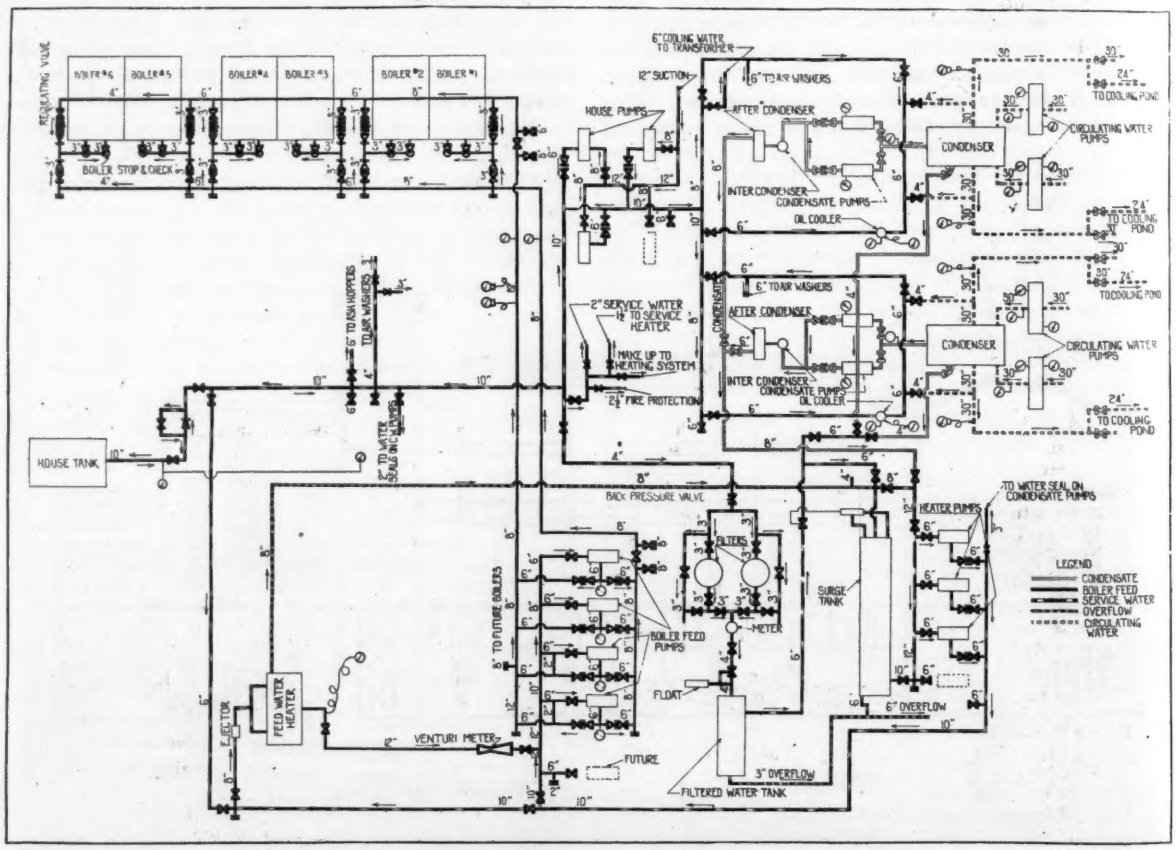


FIG. 6. HEAT BALANCE DIAGRAM OF THE STATION AS IT NOW STANDS

Summary of Mechanical Equipment at Pine Grove Station

Turbines (Main)
- Manufacturer: General Electric Co.
- Number: 2
- Rated capacity in kw: 12,500
- Rated capacity in kv. a: 15,625
- Voltage: 12,000
- Phase: 3
- Frequency: 60
- R. P. M.: 1,800

Turbines (House)
- Manufacturer: General Electric Co.
- Number: 2
- Rated capacity in kw: 1,500
- Rated capacity in kv. a: 1,875
- Voltage: 2,300
- Phase: 3
- Frequency: 60
- R. P. M.: 3,600

Exciters: Direct connected

Generator Air Coolers
- Manufacturer: Spray Eng. Co.
- Type: Air washer with closed air circulation
- Capacity (Main Turbines) c.f.m., each: 35,000
- Capacity (House Turbines) c.f.m., each: 7,000

Condenser Equipment
- Manufacturer: C. H. Wheeler Mfg. Co.
- No. units: 2
- Surface in sq. ft., each: 24,000
- Type: 2 pass with divided water box
- Size and gage of tubes: 1 in.—No. 18
- Material: Muntz metal
- No. of circulating pumps per condenser: 2
- Capacity, each in g.p.m.: 13,750
- Type: Centrifugal
- R.p.m.: 580/420
- Driven by: 2—Constant speed ind. motors; 1—580 r.p.m., 200 hp., and 1—420 r.p.m., 75 hp.
- No. of units, per condenser: 2
- Capacity, each g.p.m.: 500
- R.p.m.: 1,750
- Driven by: Ind. motor

Air Removal Equipment
- Type: Steam Radojet
- No. of units, per condenser: 2
- Inter and after condensers: Yes

Cooling Pond
- Dimensions: 498 ft. x 250 ft.
- Area sq. ft.: 124,500
- Spraying equipment, made by: Spray Eng. Co.
- Capacity in g.p.m.: 55,000
- No. of spray nozzles: 1,440

Storage Reservoir
- Present area of water surface at elevation of spillway in acres: 86
- Present available storage capacity in gallons: 195,000,000
- Station capacity at 50 per cent load factor for which present reservoir will regulate water supply, kw.: 75,000
- Station capacity at 50 per cent load factor which can be developed by increasing height of reservoir dam, kw.: 200,000

Stokers
- Manufacturer: Combustion Eng. Corp.
- Type: Coxe chain grate
- No. of units, per boiler: 1
- Length, each unit, effective: 18 ft. 4 in.
- Width, each unit: 10 ft. 8⅝ in.
- Grate surface per boiler, sq. ft.: 196.5
- Stoker drive: Var. speed, d.c. motor

Ash Hoppers
- Type: Concrete, brick lined
- Make and type of gates: The Baker Dunbar Co., air operated

Forced Draft Fans
- Manufacturer: Green Fuel Economizer Co.
- No.: 6
- Capacity, each c.f.m.: 37,500
- Speed in r.p.m.: 1,140
- Drive for each fan: 50-hp. constant speed, a.c. motor

Boilers and Superheaters
- Manufacturer: Babcock & Wilcox Co.
- No.: 6
- Heating surface per boiler, sq. ft.: 7,989
- Heating surface per superheater, sq. ft.: 1,057
- Steam condition for which boiler was designed—
  - Drum pressure lb. per sq. in. ga.: 300
  - Total steam temperature deg. F.: 625
- Type of boiler—
  - No. of tubes wide: 18
  - No. of tubes high: 20
- Size and gage of tubes: 4 in., No. 8 B.W.G.
- Length of tubes: 20 ft.

Feed Water Regulators: The "S—C" Regulator Mfg. Co.

Soot Blowers: Diamond Power Specialty Corp.

Chimney
- Built by: M. W. Kellogg Co.
- Type: Radial brick
- Inside diameter at top: 18 ft. 0 in.
- Inside diameter at base: 24 ft. 3 in.
- Height above foundation: 350 ft.
- Height above grate surface: 320.5 ft.

Boiler Feed Pumps
- Manufacturer: Allis-Chalmers Co.
- Turbine-driven pumps
  - No.: 2
  - Capacity, each, g.p.m.: 500
  - R.p.m.: 2,500
- Motor-driven pumps
  - No.: 2
  - Capacity, each, g.p.m.: 400
  - R.p.m.: 1,750
  - Type of motor: Constant speed, a.c.
- Type of control on pumps
  - Turbine-driven pumps: S-C excess pressure regulator
  - Motor-driven pumps: S-C excess pressure relief valve

Feed Water Heater
- No.: 1
- Manufacturer: Cochrane Corp.
- Type: Deaerating
- Capacity, lb. of water per hr.: 380,000

Piping and Valves
- Joints in high pressure steam lines: Sargol
- Main gate valves: The Chapman Valve Mfg. Co.
- Boiler stop check valves: The Edward Valve & Mfg. Co.
- Boiler blowoff valves: Edward & Everlasting

Coal Handling Equipment
- Furnished by: R. H. Beaumont Co.
- For elevating to bunker
  - Type: Skip hoist
  - No. units: 2
  - Capacity, each, short tons per hr.: 100
- For storage
  - Type: Drag scraper
  - Capacity of storage, short tons: 60,000
- Storage battery locomotive
  - Manufacturer: General Electric Co.
  - Weight, tons: 28
  - Rated draw bar pull, lb.: 9,000
  - Gage: Standard
  - Battery: 100 cells MV-33 ironclad Exide
- Ash car
  - Type: Air operated side dump
  - Manufacturer: Clark Car Co.
  - Capacity, level full, cu. yd.: 30
  - Gage: Standard
- Locomotive crane: Ohio Loco. Crane Co.
  - Size: 20 T.
  - Gage: Standard
- Circulating water screen
- Manufacturer: Link-Belt Co.
  - Area of screened opening to intake, sq. ft.: 121
  - Type: Revolving

Boiler feed water meter: Simplex Valve & Meter Co.

Steam flow meters: Bailey Meter Co.

High pressure steam traps. The Strong, Carlisle & Hammond Co.

Low pressure steam traps: Crane Co., tilt, three valve

at approximately 400 per cent of rating. The boiler feed pumps consist of two turbine driven pumps and two motor-driven pumps. The motor-driven pumps which have constant speed motors are provided with excess pressure relief valves and are intended to supply the base load of the boiler feed, the turbine-driven pumps which have excess pressure governors do the regulating. The number and the capacity of the pumps was selected on the basis of

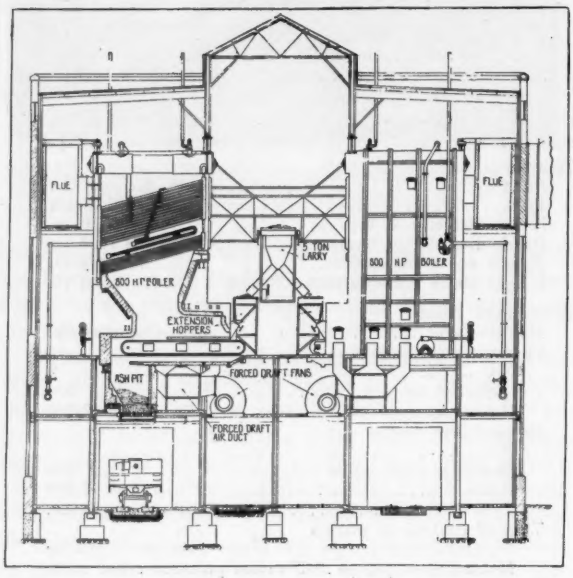


FIG. 8. ASH IS DUMPED DIRECTLY FROM THE STOKER HOPPER INTO RAILWAY CARS

having two spare pumps so as to insure water supply for the boilers under all circumstances. The feed piping between the pumps and the boilers is in duplicate.

House Turbine Installed in Duplicate

The heat balance of the station is obtained by the use of house turbines, all auxiliary drives except the two tur-

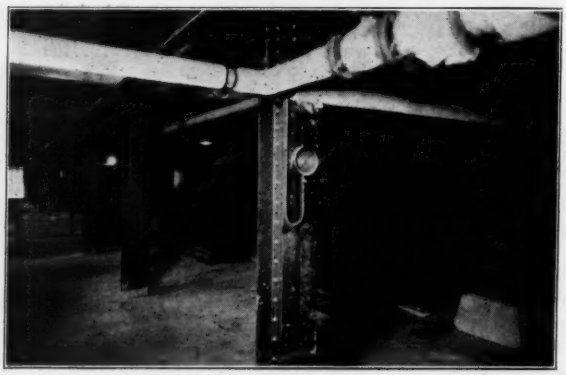


FIG. 9. FORCED DRAFT FANS ARE ON AN INTERMEDIATE FLOOR JUST BELOW THE OPERATING FLOOR

bine-driven boiler feed pumps being electric. The house turbines are installed in duplicate and the size is somewhat larger than necessary for the present requirements as it was expected that an additional main turbine would be installed in the near future. Those house turbines are connected to the main bus bars by means of transformers so that the load on the house turbines may be regulated according to the heat balance. The adjustment of the load for the heat balance is made by hand, the switchboard operator being provided with a pressure gage connected to the exhaust steam header. The house turbines are designed to operate with an exhaust pressure up to 10 lb. ga. and the most economical pressure at which to operate varies between 10 lb. and atmosphere, depending on the temperature of the condensate.

This pressure is determined for the operator and he is instructed to vary the load on the house turbine to maintain the desired pressure in the exhaust steam header, the control by the header pressure having been found extremely simple. The main condensers are the divided water box type so that one-half the tubes may be cleaned while the condenser is in operation. It is interesting to observe that the two condensers have now been in service a year without sufficient accumulation in the tubes to require cleaning.

OPERATION OF THIS PLANT SHOWS IMPROVEMENT

	July	October	11 Months 1924
Kw.-hr. generated	7,518,020	8,397,620	79,065,920
" used at station	423,580	396,060	4,217,970
" net output	6,894,440	8,001,560	74,857,950
" on maximum hour	16,800	25,000	26,400
" on maximum 10 min.	16,900	25,100	27,300
Load factor on max. hour	45.08	46.50	40.45
Lb. of coal burned	14,420,704	16,411,136	157,470,544
" " water evaporated	99,345,000	113,779,000	1,138,777,000
" " make-up water	2,704,977	1,605,061	28,181,879
Per cent gross kw.-hr. used at station	5.79	4.72	5.34
Per cent make-up water	2.72	1.41	2.48
Avg. temp. °F. Condenser Intake	78	73	65
" " " Condenser Discharge	83	78	69
" " " Exhaust Steam		91	93
" " " Condensate		88	90
" Vacuum referred to 30 in.	27.94	28.57	28.30
" Steam pressure in header	280	279	279
" " " at throttle		268	268
" " tem. deg. F.	588	600	586
" Feed water tem. deg. F.	219	217	216
" Flue gas tem. deg. F.	511	507	512
H. Boiler H.P. Hr. Operated		2,445.20	*20,317.90
H. Boiler H.P. Hr. Banked		446.40	* 6,363.40
Avg. moisture coal per cent	8.40	9.60	8.60
" ash dry coal " "	17.60	18.50	17.40
" combustible per cent in ash		16.80	16.99
B.t.u. per lb. of coal as fired	11,080	10,676	11,085
Lb. of coal per net kw.-hr.	2.12	2.05	2.10
Lb. of steam per lb. of coal as fired	6.79	6.93	7.20
Lb. of steam per net kw.-hr.	14.38	14.22	15.15
Boiler efficiency per cent.	68.60	73.06	73.85
B.t.u. per net kw.-hr.	23,800	21,886	23,237
Economy above based on railroad weights of coal, larry weights in per cent of railroad weights	98.96	96.92	98.7

* For 10 months to 12/1/24.

Two circulating pumps were provided for each condenser, one pump being connected to one-half of the water box. The pumps are each driven by two constant speed motors, one motor is rated at 200 hp. and 580 r.p.m. for operating the pump with sufficient head for the sprays in the cooling pond, and the other motor is rated at 75 h.p. and 420 r.p.m. for operating the pump when the sprays are not used. The air pumps are the two-stage steam-ejector type with inter and after condensers. They are connected to both sides of the main condensers so that if only one half of a condenser is in operation the air may be extracted on the side on which the water is circulated.

Each condenser has two condensate pumps, one of which is a spare. The pumps discharge into a surge tank which is located in the basement and which has sufficient capacity to hold 15 min. supply of the condensate at full load on the station. From the surge tank the condensate is elevated to the water heater by pumps. The make-up water is introduced through the surge tank and is controlled by a float valve in the tank. The make-up water is obtained from the stream and as it is of good quality it is not evaporated but is passed through a pressure filter and is stored in a filtered water tank over the surge tank.

The feed water heater is an open deaerating type in which the air is removed from the water by the incoming steam bubbling up through the water in the bottom of the heater. The heater is designed to operate up to 10 lb. gage pressure or under a partial vacuum, a steam ejector being provided to remove the air when operated at a temperature of less than 212 deg. F. The normal supply of water from the surge tank is controlled by a float valve on the heater and in case of failure of the water supply a second float valve is provided to supply the water direct from the house tank.

ENCLOSED TYPE OF AIR COOLING USED ON GENERATORS

Generators of both the main and the house turbines have the enclosed type of air cooling. The coolers, which are of the spray type, were made by the Spray Engineering Co. Dampers are provided so that direct air circulation may be obtained through the generators if there is any trouble with the water supply to the coolers. In the case of the main generators emergency top air outlets have been provided on the generator; however, owing to the size of these units if the hot air were discharged through dampers into the basement the hot air would quickly find its way into the inlets of the machines and cause overheating. In order to stabilize the pressure in the closed air circulating systems and prevent leakage carrying dust into the air duct, each air cooler duct is equipped with an air filter unit.

In the steam piping Sargol joints are used for joints 4 in. and larger. These joints have been satisfactory. The steam supply piping to the turbine driven boiler feed pumps is 3½ in. and the joints in these lines are of the Edwards type. This joint consists of a V-shaped groove in each face of the pair of flanges and a ring of monel metal shaped to fit the grooves is held between the flanges. The monel rings are slotted to allow them to compress in the grooves in the flanges. The smaller flanged joints in the steam lines have raised face flanges with compressed asbestos gaskets. All the high pressure boiler feed piping is genuine wrought iron pipe with steel flanges and fittings. The flanges are screwed on the pipe and welded front and back, the made up flange being refaced after welding.

For all high pressure flanged joints, both steam and water, alloy steel studs with a nut on each end are used in place of ordinary bolts. The bolting is also over size. Tests on turned down samples of the finished studs showed the material to have an elastic limit of over 140,000 lb. per sq. in., an ultimate strength over 153,000 lb. per sq. in., an elongation in 2 in. of over 16 per cent and a reduction in area of 60 per cent.

This station was designed by The J. G. White Engineering Corp.

Water-Cooled Furnace Walls Prove Successful

NEED FOR HIGHER CAPACITIES AND EFFICIENCIES LEAD TO FIN-TUBE WALL WHICH ELIMINATES TROUBLE WITH FURNACE BRICKWORK. BY H. D. SAVAGE

FOR SEVERAL years, engineers have been aware that development of refractories and material for furnace walls has not kept pace with progress in other departments of power plant work, in spite of the good work that has been done by the Refractories Manufacturer's Association acting through the Mellon Institute and that done by the Bureau of Mines. The refractories available at the present time, although they may be able to stand up under laboratory tests, cannot meet the requirements of modern high settings, high ratings and high efficiencies without some artificial aid. This led in the beginning to the development of ventilated blocks and later to the working out of steam-cooled walls and water-cooled walls.

Although the hollow-wall furnace was a tremendous step forward, it is more practical with powdered fuel than with stokers. In using steam-cooled walls, the amount of cooling that can be obtained depends on the area that can be exposed to the furnace, which is limited by the amount of superheat required; the results obtained so far indicate that this method is still in the experimental stage. The completely water-cooled furnace, or a combination of this with refractories, seems to offer the greatest possibilities for future interest, and it is with this type that this paper will deal.

In particular, we shall discuss one type of water-cooled furnace, the finned type, which has been applied to both stoker and pulverized fuel installations. While the net effect of such walls on capacity and economy is not very well known, it is possible to discuss them from an operating standpoint, since three of them have been in use over stokers at Hell Gate for over a year and six at Sherman Creek for several months. Results of the operation of these nine furnaces indicate that the fin furnace is at present a reliable article of commercial merit, capable of materially reducing upkeep and lessening outage time necessary for brickwork repairs.

Prophecies made as to burning of fins, erosion of tubes and reduction of efficiency by too much cooling, in the Hell Gate furnaces, have not been fulfilled. There has been no erosion, although the original boiler so equipped has been operating since December, 1923, at ratings up to about 600 per cent, with efficiencies as high as those produced anywhere in the country, the latter indicating that excessive cooling has not occurred. Although most of the designs so far embody a combination of water tubes and brick, the indications are that the complete metal furnace has advantages over anything yet offered.

Welding of the fins to the tubes makes such a complete bond that the heat transfer through fins and tubes is almost equal to that through the tubes alone. Some tests are being planned to furnish data on velocity, absorption and radiation. Recent tests on a Lopulco water screen at Cahokia indicate an absorption on the horizontal tubes of about 80,000 B.t.u. per sq. ft. and on the vertical side tubes of almost 75,000 B.t.u. per sq. ft. This would indicate that the water wall has an efficient absorption surface, as well as that the cooling effect does not interfere with efficiency.

It has been found, too, that the capital expenditure required for fin furnace construction is not much more than that for the latest type of refractory furnace. In fact, if credit is given for the additional heating surface gained, the cost chargeable to the furnace will be slightly less than with other methods.

Figure 1 shows an isometric view of the water wall installation at Hell Gate, a cross section of the same in-

stallation being shown in Fig. 2. The side walls consist of 4 in. tubes spaced on 7⅜-in. centers; each tube has two longitudinal steel fins welded to it as shown, the fins overlapping, when the tubes are in position, to present a continuous water-cooled surface to the radiant heat. The lower part of the tube is covered by fireclay tile, extending the length of the furnace for a short distance above the stoker, but in future installations the refractory wall may be replaced by metal blocks.

Since the lower ends of the tubes are connected by a header to the mud drum of the boiler and the upper ends

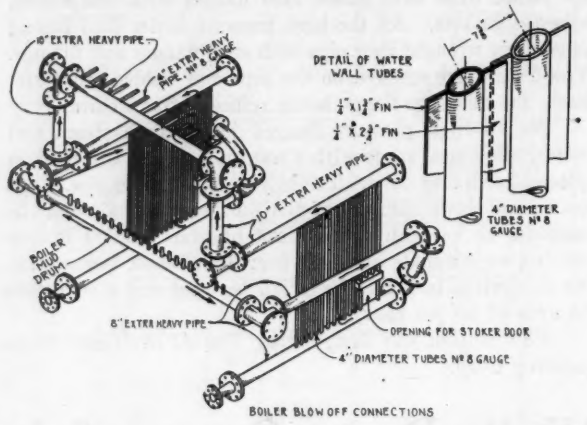

6" EXTRA HEAVY PIPE
4" EXTRA HEAVY PIPE - Nº 8 GAUGE
DETAIL OF WATER WALL TUBES
¼" X 1½" FIN
½" X 2½" FIN
10" EXTRA HEAVY PIPE
4" DIAMETER TUBES Nº 8 GAUGE
BOILER MUD DRUM
8" EXTRA HEAVY PIPE
OPENING FOR STOKER DOOR
4" DIAMETER TUBES Nº 8 GAUGE
BOILER BLOW OFF CONNECTIONS

FIG. 1. ISOMETRIC VIEW OF WATER SCREEN AT HELL GATE

to the boiler drum, the water in the water-wall forms a part of the boiler circulation.

Not only do the water walls replace most of the side wall brickwork, but they also absorb considerable heat reflected from the front and rear walls, thus protecting these surfaces.

To those familiar with the difficulties of brickwork maintenance, the logic of the water-cooled wall is at once evident. With large settings this brickwork maintenance is a considerable item, but the loss in capacity of equipment out of service for repairs is even more important. In the past, using smaller boilers, a major brickwork repair job could be completed over a week-end or holiday period. Now, however, with larger settings, several days are needed. Furthermore, each boiler represents a larger proportion of the total capacity than it did in the older stations with a large number of small boilers. Then, too, early types of stokers required considerable time out for repairs, at which time the brickwork could be looked over.

Now that the tendency is to use larger boilers with pulverized fuel, resulting in ability to operate for longer periods without shut-down, it seems well to eliminate the limiting factor that brick walls naturally place on such an installation.

Another tendency is towards the use of preheated combustion air, which, in combination with pulverized fuel, makes possible high ratings and high efficiencies, but results in intense heat in the furnace and makes the use of water-cooled walls almost imperative. Under such conditions, using water-cooled walls, there is no more liability of shutdown than is caused by the boiler itself.

At Cahokia a water-cooled furnace is now being applied in combination with air-cooled refractories to an 1800-hp. boiler. So far all the operation shows that there are no disadvantages from cooling. We know from experience that completely water-cooled furnaces, such as on locomotives or Lancashire boilers, are used at high ratings with good efficiency.

Fin furnaces may be applied to any type of firing with pulverized fuel, fuel oil, or stokers. They may be applied to existing plants on large or small boilers, in many cases without changes in the present settings, by installing the tubes in front of the brickwork. This would probably end the necessity for continuous repairing, which is necessary if the boiler is being worked at high rating.

Often we hear engineers say, "Oh, well, I don't have much brickwork repair and I wouldn't be justified in putting in water-cooled furnaces." If true, this statement means that a large capital investment has been made to operate boilers at a low rating or else that combustion efficiency is not what it should be.

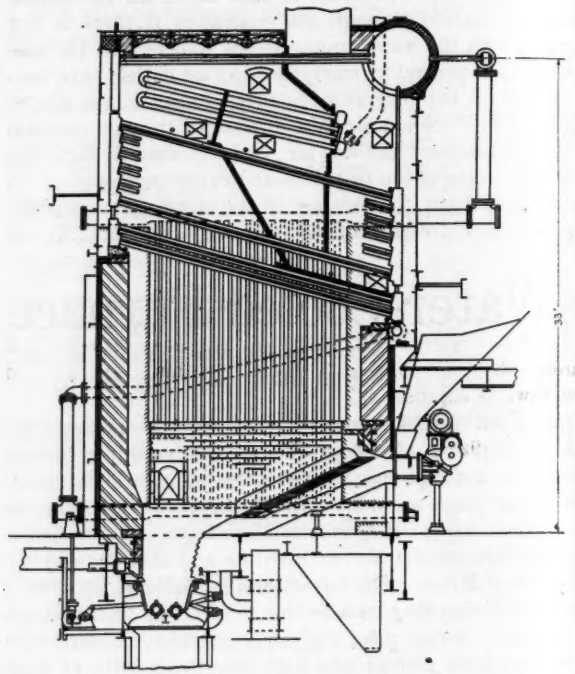


FIG. 2. SECTION OF BOILER, SHOWING SMALL AMOUNT OF BRICKWORK ON SIDE WALLS

Rating methods of not more than a year ago have been made obsolete by the high cost of boilers and accessories and the proved ability of modern firing methods to produce high ratings for long periods with high economy. On this account, the progressive engineer should discard boiler horsepower calculations and consider only evaporation per sq. ft. of heating surface, bearing in mind that the pounds of coal possible to fire efficiently under a boiler today bear no relation to his calculations of yesterday. This is most strikingly illustrated in the case of a new station projected for the eastern part of this country, where the original figures made on the basis of underfeed stokers operating under the most favorable conditions, showed a necessity for 44 boilers of approximately 15,000 sq. ft. heating surface each and where the present figures, revamped to cover pulverized fuel firing which has been adopted for this station, indicate a necessity for only 32 boilers of approximately 15,000 sq. ft. heating surface. These 32 boilers, operating at the higher rating made necessary by the fewer boilers, will produce, at the average rating at which they

will be required to operate 62½ per cent of the time, 1.5 per cent higher efficiency than would have been possible with the 44 boilers at the lower average rating that would have been required. This consideration of modern equipment in this plant made a capital investment reduction of approximately $4,000,000 on the boilers and boiler accessories alone and this does not take into consideration the saving made in very high-priced real estate.

It is quite possible that in many plants where new boilers are contemplated, the addition of the fin furnace would permit much higher ratings and efficiencies, so that the purchase of the additional boilers might be postponed for several years.

Some question has been raised as to the effect that welding of the fins might have on the strength of the tubes. We have made numerous tests on finned and unfinned tubes and find that there is practically no reduction in the strength of the tube due to the welding of the fin. The writer recently saw a hydrostatic test of a 4-in. 6-gage tube, 4 ft. long, on 2 ft. of which fins had been welded, the other 2 ft. being plain. The pressure was run up to 6000 lb. per sq. in. when a leak developed in the end plug but no bulge or rupture occurred anywhere in the vicinity of the fins. The standard rupture test for a tube of this type is 6200 lb.

It is believed that the fin furnace is a practical operating apparatus, offering opportunities for increased capacity, greatly reduced maintenance, with equal if not better efficiencies, and reduction of outage. These brief notes are offered in the hope that they will stimulate discussion and arouse the interest of all engineers in this successful and worthwhile engineering development.

In discussing this paper, which the writer presented on Jan. 14, 1925, at the second annual meeting of the Chicago section of the A. S. M. E., Mr. Heaton of Sargent and Lundy stated that at Calumet a water screen was used without fins and after nine months' operation no trouble arose from burning out of tubes and no damage resulted to the brickwork behind the tubes. He believed that the same results will be secured by a plain tube surface as by the fin tubes.

Mr. Chamberlain of the Staley Mfg. Co. announced that at his plant two new 897 hp. boilers are being installed, one equipped with a brick furnace, the other with a water wall. After several months of operation, measuring the evaporation under actual working conditions, the fire brick wall of the first boiler will be replaced by a water wall and another series of test run over a period of several months.

C. W. E. Clark remarked that the water-cooled wall inserted in fire-brick used at the Allegheny County Steam Heating Plant has come up to all their expectations.

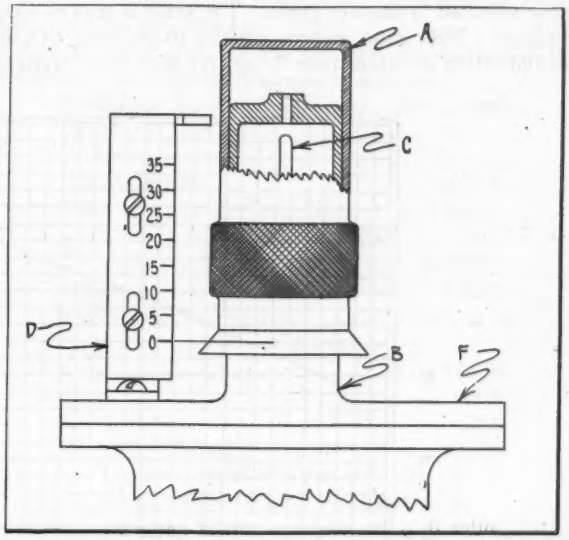
At Colfax, he said, use of air preheaters had led to erosion in the furnaces which will undoubtedly be stopped by the use of fin-tube walls. With preheated air, some way of cooling the walls other than by air is absolutely necessary.

BLOWOFF VALVES and blowoff cocks should never be jammed or forced tight shut. Great danger lies in the practice of attempting to stop a leak through a blowoff valve or cock by jamming it shut with a long wrench or pipe. The seats of these valves should be watched carefully and frequently renewed.

Air Leakage in Condensers Detected by Air Meter

GOOD performance of surface condensers depends on the correct quantity of circulating water, the cleanliness of the tubes, the air leakage into the system and the efficiency of the air pumps.

By taking temperature readings, the quantity of circulating water can be checked. Periodic inspection will show the condition of the tubes. A test will show the condition of the pumps. But the amount of air, which is practically all leakage, gives no indication except lowered vacuum. This lowered vacuum may be due to any of the items listed, but it is not always possible to make the routine tests necessary.



SKETCH SHOWING CONSTRUCTION OF AIR LEAKAGE METER

To get a good indication of abnormal air leakage while running, an air meter as shown in the figure may be installed on the ejector, according to H. M. Graham in Powerfax. A is a sliding cylinder or air bell riding on another cylinder B which has several slots C. A maintains a slight constant back pressure on the ejector and the vertical movement of A is directly proportional to the quantity of air handled, which is indicated on scale D.

Interesting applications of this meter can also be made in determining turbine performance and preventing leaks in casings and piping on the low pressure side. In one case, the air leakage was 20 cu. ft. per min. on a large turbine as the load increased from 5000 to 10,000 kw.

Since the quantity of air flowing through an orifice is constant as long as the pressure on the low side of the orifice is less than 55 per cent of the pressure on the high side, it was figured that with a 29.9- in. barometer, this low pressure would be 13 in. of vacuum. By consultation with the turbine manufacturer, it was found that at a load of 10,500 kw. a certain point in the low pressure side of the turbine was at this pressure. In this particular case, the leak was found in the extraction heater piping. After the leak was stopped, the vacuum was increased about 0.1 in. and it was possible to shut down one-half of the air ejector.

Calculation of Heat Lost in Flue Gas

PROXIMATE ANALYSIS OF COAL AND FLUE GAS ANALYSIS FORM BASIS OF FORMULA FOR HEAT LOST IN DRY GASES. BY N. T. BOURKE

FOR ANY given coal and temperature of flue gas, it is possible to draw up a table showing the relationship between stack loss and CO_2 but it is impossible to apply this table to any other coal or any other temperature. Every boiler operator knows that the method of firing which gives best results with one grade of coal may be quite unsuited to another grade. The same is true of CO_2 readings. With most eastern coals a 10-per cent CO_2 is an indication of rather poor firing, yet with many western coals 10-per cent CO_2 is about the best obtainable. Each grade of coal is an individual problem and it is unwise to generalize.

At the same time, no great knowledge of chemistry or mathematics is required for ordinary power plant work. Formulas exist which, if carefully applied, will give the stack heat loss with sufficient accuracy for the great majority of cases. Of these formulas, the most comprehensive and reliable is (1)

$$W = \frac{11\ CO_2 + 8\ O_2 + 7\ (N_2 + CO)}{3\ (CO_2 + CO)} \times \left(C + \frac{6}{11} S\right)$$

which gives the weight of the dry products of combustion per pound of fuel. In this formula, CO_2, CO, O_2, and N_2 are the per cents of carbon dioxide, carbon monoxide, oxygen and nitrogen as obtained by an Orsat (or flue gas analyzer), and C and S are the per cents (expressed decimally) of carbon and sulphur in the ultimate analysis of the coal.

The heat loss in the dry products of combustion per

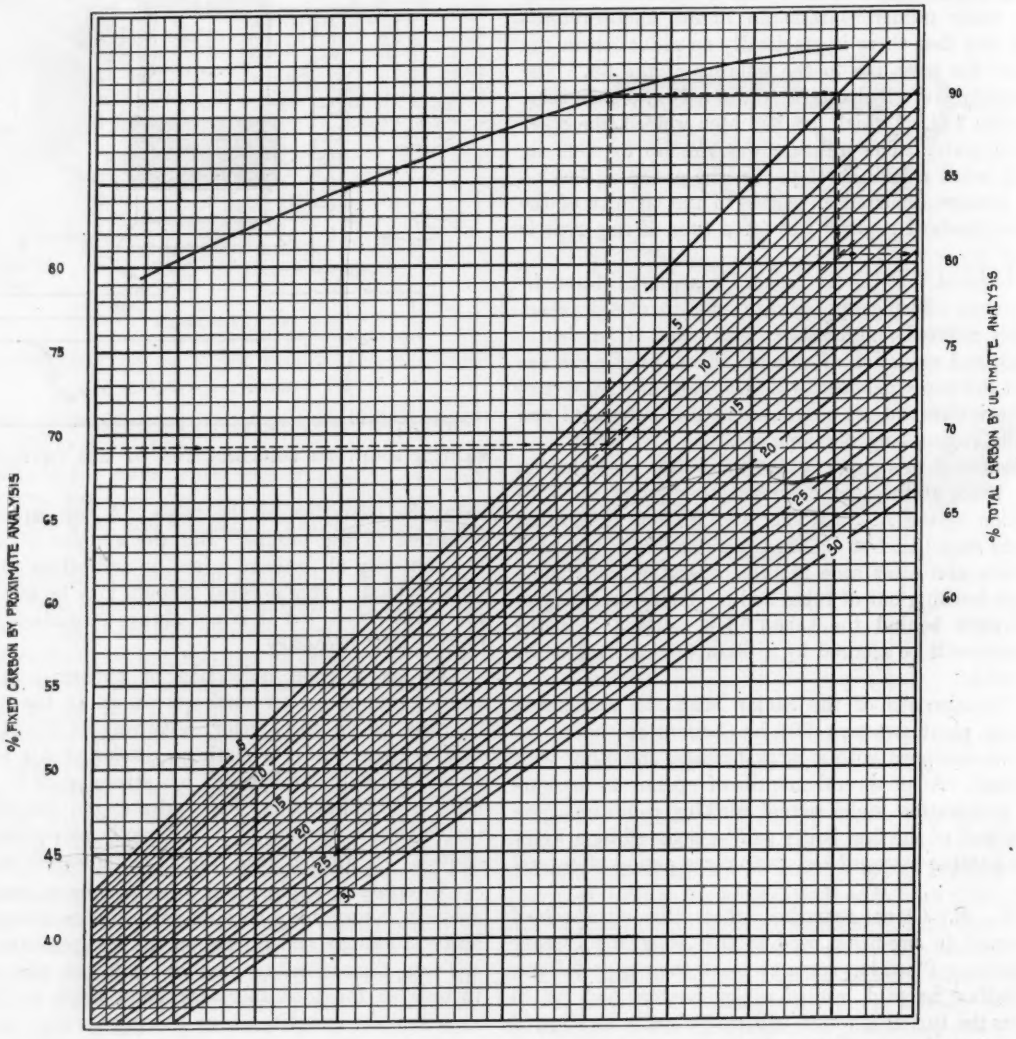


CHART FOR DETERMINING THE TOTAL CARBON OF COAL FROM THE PROXIMATE ANALYSIS

From the value of the fixed carbon on the left, read horizontally to the sum of moisture and ash on the diagonal lines, then vertically to the curved base line, then horizontally to the 45 deg. base line, then vertically to the sum of moisture, ash and sulphur on the diagonal lines, then horizontally to the scale on the right. Read the value of the total carbon on this scale.

pound of fuel may then be calculated from the formula

$$HL = W \times (T_g - T_a) \times 0.24^* \qquad (2)$$

where HL is the heat lost per pound of fuel, W the weight of the dry products of combustion per pound of fuel as determined from formula (1), T_g the temperature of the flue gas and T_a the temperature of the air.

The per cent stack loss in the dry products of combustion may then be determined by the formula (3)

$$\% \text{ stack loss} = \frac{\text{Heat lost per pound of fuel}}{\text{Heat content of fuel per pound}} \times 100\%$$

These three formulas will give entirely correct and satisfactory results for all grades of fuel; it should be emphasized, however, that the loss due to the dry products of combustion is not the only stack loss. All coal contains hydrogen, in amounts varying from one to five per cent, which upon combustion with oxygen forms water vapor. This water vapor appears in the flue gas as the wet product of combustion. Unlike the dry products, it is a fixed amount beyond the control of the boiler operator. And since it is a fixed loss, which cannot be reduced, it is useless to consider it in ordinary work which has as its object the reduction of avoidable losses. In accurate boiler testing it must be considered but in routine daily testing it may be disregarded.

In passing it may be mentioned that, owing to the presence of this water vapor in the flue gas, it is impossible to have the per cents of CO_2, O_2 and CO as determined by an Orsat add up to 20.9 per cent. The sum of these constituents will always be less than 20.9 per cent, the exact amount less depending on the per cent of H_2 in the coal and the amount of excess air supplied for combustion. It is not possible, therefore, to omit the O_2 determination in flue gas analysis and to assume that the O_2 is equal (neglecting CO as negligible) to 20.9 — CO_2.

In formula (1) C was given as the per cent carbon in the fuel by ultimate analysis. The ultimate analysis of coal is, however, a difficult and expensive matter—much more so than the proximate analysis. The proximate analysis of a coal is often available, where the ultimate is not. By means of the accompanying chart, however, the total carbon by ultimate analysis may easily be obtained from the proximate analysis. This chart is based on the proximate and ultimate analyses of 106 coals from as many mines, in Pennsylvania, Maryland, Virginia, West Virginia, Kentucky, Ohio, Indiana, Illinois, Iowa, Missouri and Kansas. This chart, for the coals from which it was plotted, has an accuracy as follows:

State	Maximum Error	Average Error
Pennsylvania	1.54%	.4%
Maryland	1.35%	1.3%
Virginia	2.63%	.9%
West Virginia	1.49%	.7%
Kentucky	2.92%	1.2%
Ohio	1.59%	.9%
Indiana	2.48%	1.2%
Illinois	2.40%	1.1%
Iowa	1.79%	1.1%
Missouri	2.09%	1.0%
Kansas	2.20%	1.5%

It is fair to assume, as repeated test has indicated, that for other coals from the same localities the chart will have about the same average error as indicated above. It can hardly be applied to coals from other localities, however. Wyoming and Colorado coals, for instance, will not check closer than four or five per cent. But for the great majority of steam coals used in this country this chart can safely be used.

The sulphur content of coal is easily determined and is usually appended to a proximate analysis. It is not included in the proximate analysis, but separately reported, and its value is the same as would be given in an ultimate analysis. The sulphur content of coal as customarily reported in a proximate analysis is, therefore, the correct value of S in formula (1).

As an illustration of the practical application of the foregoing, the following example is appended.

Proximate Analysis. (Cambria, Penn., coal)

Moisture	2.87%
Volatile	21.44%
Fixed carbon	69.23%
Ash	6.46%
Total	100.00%
Sulphur	1.52%

Heat value, "as received," 14,177 B.t.u. per lb.

Flue Gas Analysis.

CO_2	12.0%
O_2	6.8%
CO	.2%
N_2 (by difference)	81.0%

Temperature of flue gas, 460 deg. F.
Temperature of air, 60 deg. F.

The total carbon by ultimate analysis is found from the fixed carbon by proximate analysis by use of the chart. This particular case is the one used to illustrate the use of the chart. Following the dotted line, the total carbon is read at 80.5 per cent. (By ultimate analysis this coal is actually 80.53 per cent carbon.)

By substituting values in formula (1)

$$W = \frac{11 \times 12.0 + 8 \times 6.8 + 7\,(81.0 + .2)}{3\,(12.0 + .2)} \times \left(0.1805 + \frac{6}{11} \times 0.0152\right)$$

$$W = 16.75$$

By substituting values in formula (2)

$$HL = 16.75 \times (460 - 60) \times .24$$

$$HL = 1607.9$$

By formula (3)

$$\% \text{ Stack loss} = \frac{1607.9}{14{,}177} \times 100 = 11.4$$

In an address before the American Chemical Society, Alex Dow of the Detroit Edison Co. stated that the controlling reasons for use of pulverized fuel at Trenton Channel were the ability to use many kinds of coal efficiently, and reduction of unconsumed fuel in the ash. He did not think that furnace efficiency is altered if the same furnace temperature and delivery of radiant heat is maintained by use of pulverized fuel or stoker. But the powdered fuel furnace is adaptable, by minor adjustments, to a great variety of coals, thus widening the possible sources of fuel supply.

All fuel oil storage tanks should be properly vented.

*0.24 in formula (2) is the specific heat of average representative flue gas, and may safely be taken as the specific heat in any case where extreme accuracy is not required.

Foundations for Steam Turbines

CONVENIENCE AND EFFICIENCY MAY BE SACRIFICED BY POOR DESIGN AND CONSTRUCTION. BY WALTER SLADER

ENGINEERS WHOSE efforts have been devoted to the study and design of steam power stations and who have thus compared many installations can not have helped notice the change in style of turbine foundations. They can not have helped noticing, too, that this item of the equipment has often been given far less thought or attention than its real influence on the proper and convenient handling of the station would justify. Much of our earlier thinking and practice, through which the steam turbine was developed, had as its background previous thinking and practice in connection with the reciprocating steam engine.

It was natural that when the early steam turbine designer, and more especially the operating engineer or practical mechanic, sought for proper forms, outlines and details of construction of foundations to support the new power units, they should turn to the nearest thing like them in their previous experience and model the new structures rather closely on the general lines of reciprocating engine foundations to which they had become thoroughly used. A horizontal engine is ordinarily a much less self contained unit than a steam turbine generator. Owing to its reciprocating motion the engine transmits much larger and more varying forces to its foundation. The steam engine could not make use of high vacuum to the same extent as the steam turbine. Condensers were smaller, auxiliaries much simpler; it did little harm to have the condenser connected to the exhaust flange by means of a considerable length of moderate sized pipe and it took only an ordinary sized corner to accommodate the whole equipment.

For all of these reasons the standard engine foundation was a solid block of masonry, and the early horizontal shaft turbine generator foundation often tended to be much the same, pretty thoroughly filling the space directly under its unit with solid walled masses of concrete.

This elementary type of foundation is undesirable because of the hindrance it offers to the proper placing of condenser and auxiliaries. Its worst effects are perhaps seen in industrial plants where basement space is limited. Here such construction has often resulted in placing condenser and auxiliaries where they could not be efficient and where some or many parts of the equipment could not be conveniently cared for and repaired.

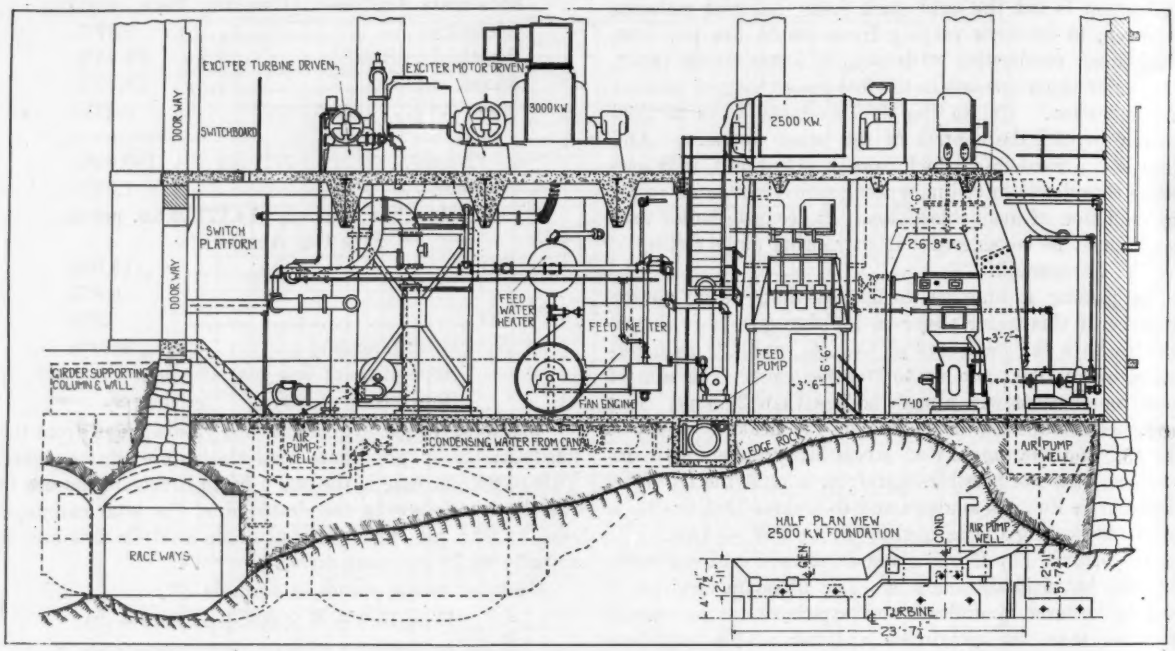


FIG. 1. THESE FOUNDATIONS WERE PLACED IN THE SPACE FORMERLY OCCUPIED BY TWO ENGINE UNITS

Owing to simplicity of construction and low first cost, this type has tended to persist in some quarters where its high cost in final station results has not been appreciated. It is possible that the continuance of this type has, to some extent, been suggested and unintentionally encouraged through its perfectly proper use by the turbine builder as the simplest, most direct, and standard outline by which to hand on to his customers' engineer the essential facts as to general outlines of foundation. The arranging of a foundation to support the machine and cause least interference with other equipment, must be a matter of careful investigation and special design for each case. This requires a considerable, sometimes a large, expenditure of time on the part of a trained engineer and is expensive but is an expense which should return ample dividends in resulting convenience and low cost of station operation.

REQUIREMENTS OF A TURBINE FOUNDATION

Having seen why certain forms are not desirable, we may well make a list of the several things which should, so far as is possible, be embodied in a good foundation. We can then consider various forms which experience has

shown will meet these requirements, and take up details of their construction. Requirements for a satisfactory steam turbine foundation are as follows:

1. A firm, stable, non-vibrating support for the turbine.
2. A similar support for such parts of condenser, pumps and auxiliaries as come within its borders.
3. Condenser to be directly connected to turbine, or so placed that there may be no appreciable loss of vacuum between condenser and turbine exhaust flange.
4. Condenser to be so placed that the total head against which condensing water must be handled may be as little as practicable.
5. Condenser pumps, condensate pumps, vacuum pumps, and other auxiliaries to be so placed that their connections may be short, direct and efficient, causing minimum losses throughout.
6. Convenient location for such air pump water supply and discharge tanks as may be necessary.
7. Access to all steam joints which require being kept tight.
8. Convenient access for cleaning condenser tubes, nozzles, jets or other working parts.
9. Ample space around all auxiliaries for handling, access, cleaning and repair.
10. Space for water connections to and from condenser.
11. Space for properly taking off atmospheric exhaust connection, with proper support for and access to relief valve.
12. With extraction type turbines, space for convenient location of all part pressure steam lines with their special control and shutoff valves, also space for heaters when used.
13. Space for air supply into and out of turbine generator, with convenient location for air ducts, air filters, washers, or air coolers, if used.
14. Proper means for bringing in exciter cables, and taking out main generator leads, in a way that these may be rightly spaced and supported, while being carried through a cool air space away from interference with machinery or piping and free from danger of damage from steam or water leaks.
15. Provision for supporting all screens, floor plates and accessories necessary to make a neat convenient unit, easy to keep in condition and work around.

This list is not complete but is extensive enough to prove that a turbine foundation determines conditions for everything else in its vicinity. It shows why no one form can always be the best and makes clear that a good method of arriving at the one of several forms best adapted will be to choose the various units, which are to make up the station equipment, not only with reference to their individual worth, efficiency and first cost but also with reference to their adaptability to a favorable placing and grouping in the space available.

Frequently a sturdy reinforced concrete structure with outlines considerably like those of the block type but cut away to the extent necessary to accommodate condenser and other equipment, will offer the simplest and a satisfactory form. When somewhat more space under the turbine is necessary, a reinforced concrete column and girder structure, independent of building columns and girders, may prove desirable.

Under certain conditions, when still more room is needed as when the design of the turbine exhaust nozzle and bed plate require the providing of rigid support for heavy loads within narrow spaces and at the same time reasonable access to nozzle flange bolts, a steel column and girder structure armored with concrete to lessen likelihood of vibration, may be satisfactory. Sometimes, when the maximum clear space under and around turbines is required, or for other special reasons, the most satisfactory way to support the machine will be by means of specially designed columns and girders which serve at the same time both as foundation and part of the building structure.

The first requisite for any turbine foundation is a suitable footing. Temperature variations will, of course, cause slight changes but these are ordinarily less than need be considered. If practicable, foundations should be carried to solid rock or to firm, slightly compressible soil,

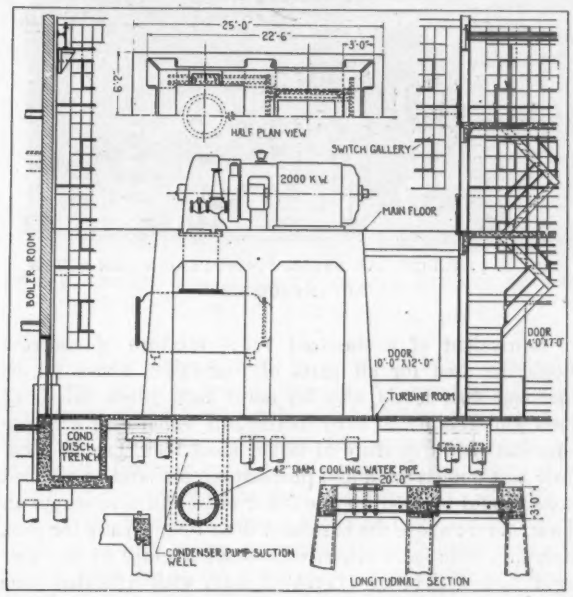


FIG. 2. CONCRETE COLUMN AND GIRDER TYPE OF FOUNDATION FOR A 2000-KW. UNIT

so located as not to be in danger of ever being undermined or disturbed by any changes. The material under all parts of the foundation should have the same bearing value, and should be as much compacted as practicable before placing concrete. Spread of footings should depend upon material on which they are placed. If the bearing power of a foundation site is in any way in question it should be determined by careful, thorough loading tests.

Piling May Be Resorted to

If extension of foundation to suitable material is not practicable wood, or preferably concrete, piles driven to solid material should be used. If wood is used the tops must be kept below a permanent water level. Piles should be sufficient in number to support the entire weight of all material which may come upon them under the worst load conditions and should be so spaced that each shall take its proportionate load. Unless driven to rock, they should be given considerably less loading than would be allowed for building foundations. If a relatively thin slab is used on top of the piles or hard soil, this should be sufficiently reinforced with steel rods to assure distributing loads evenly to all parts without danger of cracking or shearing.

Space between lower foundation slab and top of foundation should ordinarily be enough to allow placing the condenser directly under the turbine. Part of this spac-

ing may be in the form of a pit below the basement level; this is sometimes necessary but there should be as little going down into pits and climbing on to platforms as possible. Where practicable, the distance between main and basement floors should be sufficient to accommodate equipment for the largest unit ever to be placed in the station. When pits must be used, openings on to basement floor level should be protected by a four to six inch high curb to keep out water; pit floors should drain to a suitable sump, with positive means for removing water and keeping everything dry and clean at all times.

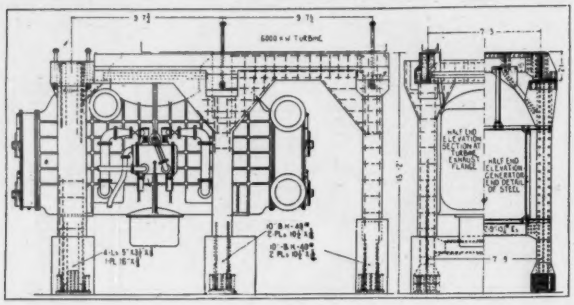


FIG. 3. STRUCTURAL STEEL FOUNDATIONS ARE OFTEN ADVANTAGEOUS

Equivalent of a standard 1:2:4 mixture of concrete should be used for all parts of foundation above pit or basement floor levels, also for lower slab, unless this is of mass construction to hard footing, in which case a leaner concrete with a mixture of larger sized rock may be used. Only best quality sand and properly sized gravel or crushed stone should be used for the lower slabs and throughout in the structure above the basement floor line. Walls for pits, air pump wells, and other parts which require to be water tight may well be of a 1:1½:3 mix, with hydrated lime added to give a still denser concrete and with ample expanded metal, or similar reinforcing, especially at all corners and joints.

As to the best way to support turbine room floors around foundations, engineering opinion differs somewhat. It would be ideal if they all could be kept entirely free from these foundations, and this separation should always be as complete as is practicable. Since sufficiently sturdy columns to be free from danger of vibration, when placed near a foundation, take up much valuable space and usually get badly in the way of properly placing and caring for equipment, personal experience has indicated that a compromise is worth while and that no serious difficulty should be experienced if the floor slab is entirely separated from foundation by a 1 or 2-in. wide slot, while the ends of floor beams are supported on plates grouted to level in pockets or on brackets which form a part of the foundation. When this is done, these beams should be kept entirely clear of the foundation except at the necessary bearing points and should be free to move on these as temperature or loading changes may require. The slot around the foundation may well be covered with 3 by ⅛-in. steel plate strips, cut to fit and held in place by a fin projecting loosely into a slot.

Opening through top of foundation should either be protected by toe boards, or better, when all pipes are in place, covered by easily removable floor plates. In this way, dirt and dust will be kept from passing from main floor to machinery below. The same rules, which apply to the design and construction of similar parts of other high grade concrete and steel structures, apply in general to the design of concrete or structural steel turbine foundations, except that, since these require to be specially rigid and free from liability to be set in vibration by high speed machines, much lower unit stresses should be allowed than in ordinary structures. Columns should be relatively massive, with ample vertical and hoop reinforcing; beams should be of such cross section, and so reinforced as to carry their loads with no appreciable deflection.

Standard Structural Shapes May Be Used

When heavy loads must be concentrated in small space, with material cut away for access, it will often be found convenient to use standard I-beams, with their ends buried in adjoining masses of concrete, the beam sections being covered with wire mesh reinforcing and concreted to form a solid structure. Two 6-in. channels fastened together back to back with spacers and so placed as to serve as bearing surface for a foundation bolt washer sometimes not only distribute the load well but permit more cutting away of concrete than otherwise would be desirable. Pockets for foundation bolt lower end nuts should be deep

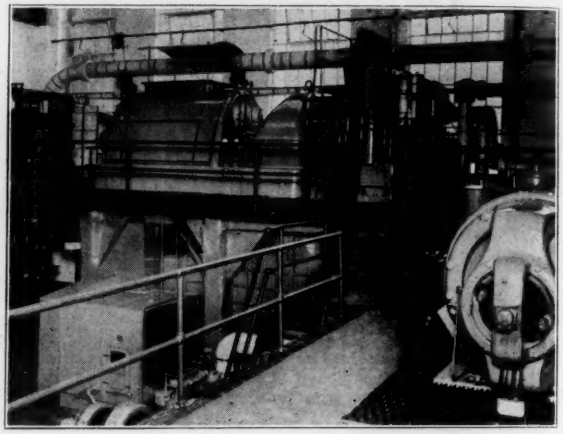


FIG. 4. CONCRETE MAY BE USED AS A COVERING OVER A STEEL FOUNDATION

enough to let bolts drop below the top of the foundation.

All points where parts change section or join in a way so as to be liable to crack should be well reinforced and special care should be taken to have all important parts true to the intended dimensions. Forms should be of good, straight, true lumber, planed on both sides to even thickness. They should be so built as to be tight, smooth on the inside, plumb, square or true to designed outlines. All important dimensions should be checked as work progresses and if not right made so. Location of turbine nozzles and foundation bolts, also overall height and final height should be checked with special care. Foundation forms should be thoroughly fastened together, stayed and braced as the load of wet concrete they are to carry is heavy.

Pockets for foundation bolts may be made by use of thin wood square forms about 2 in. larger each way than the bolt. Do not use pipe for this purpose. One way to assure that these are kept properly in place is to make them long enough above the foundation that they may be fastened to the underside of a templet on which center lines of machine and bolt holes are laid out; this templet to be

accurately placed at a convenient time during the filling of forms. All reinforcing steel should be carefully wired and fastened in true position, so that it will not be moved by the thorough spading necessary to make concrete completely fill all parts of the form and give a dense, smooth, solid structure.

Foundation should be rough finished ¾ in. to 1 in. below level at which turbine bed plate is to be placed, to allow wedging machine to exact position and final grouting. Enough metal wedges should be used to support bed plate without danger of warping. No bed plate can reasonably be made heavy enough to be free from this danger unless carefully handled. Grout should extend well above the bottom of the bed plate and out to cover wedges completely. Before it becomes hard it should be carefully

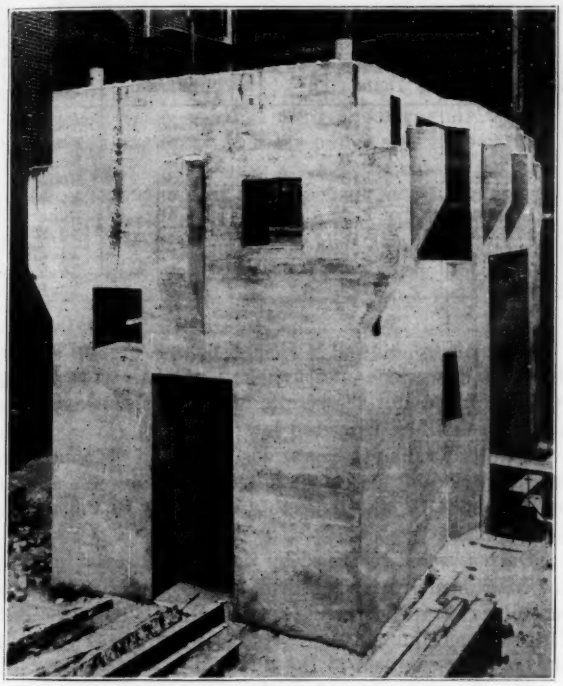


FIG. 5. REINFORCED CONCRETE FOUNDATION FOR A 7500-KW. UNIT

troweled and finished to final shape. Grout can not be gotten up into spaces above the bottom of the bed plate unless there is ample means for air to get out of these spaces, therefore see to it that this means is provided.

When the concrete of foundation has become well set, but not too hard, remove forms, patch all small imperfections by troweling in a rich sand cement mixture and smooth all surfaces by use of carborundum brick. It is easier to keep up the discipline of a properly cared for station if all surroundings are neat and attractive. This little final finish on a foundation pays more than it costs.

Figure 1 shows outline elevation of a turbine room in which two of the forms of foundation previously mentioned were used. It was chosen because this use illustrates many of the points which have been mentioned. This turbine room is situated in a section of plant so built in that extension would be difficult. It occupies the former floor space of two twin Corliss engines. When the first 3000 kw. unit was placed, it was desired to continue one of these engines in use, therefore only the space up to just beyond the condensing water pipe was available. Within this space it was desired to be able to install two such units, and also provide suitable space for an induced draft fan engine, complete piping system and boiler feed pumps. This space was directly above poorly constructed water wheel tail races, which could support no further loading. Space was extremely valuable. The building column and girder type of foundation best met all requirements and proved satisfactory. Steel girders were designed, using an

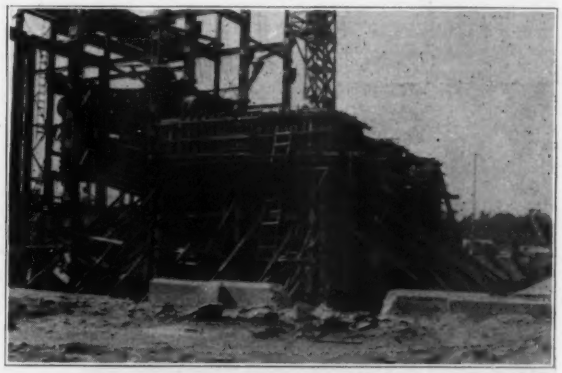


FIG. 6. FORMS FOR CONCRETE SHOULD ALWAYS BE WELL BRACED AND STAYED

extreme fibre stress of 8000 lb. or one-half the usual value. Care was taken to provide freedom for expansion of these girders at the building wall ends. Before the second, or 2500-kw. unit, was installed the remaining space was available, footings could be to rock, and only part of remaining open floor space need be covered.

Under these conditions, a modified block concrete form, with wide open spaces extending through both ways gave ample room for access to all parts of condenser and equipment.

Figure 2 shows the outline of a concrete column and girder type foundation for a 2000-kw. unit, with surface condenser in a new station where two other 750-kw. units were installed and space provided for one larger unit. All condensers took water from a common supply duct, and discharged through short sealed pipe connections to an overflow trench. The foundations gave much space under the units and allowed a good placing of all equipment. These footings were on concrete piles.

Figures 3 and 4 show details of a structural steel foundation for a 6000-kw. unit. It can readily be seen how this construction enables the full use of space to advantage. Concrete covering was put on with cement air gun.

Figure 5 shows a reinforced concrete foundation for one of two 7500-kw. turbines placed in an extension of an old turbine room. This picture illustrates the use of a pit under the turbine to give the required depth and ample space was afforded for LeBlanc type condenser with its drive. It also shows the provision for supporting part of the floor beams from foundation, with floor otherwise free, as previously mentioned. Figure 6 gives details of the forms used for foundation shown in Fig. 2 and clearly brings out the heavy construction and thorough bracing necessary.

THE INSURANCE boiler inspector is your best friend; do not antagonize him or keep things from him. Talk to him freely and get his advice.

Test of a Multi-Stage Steam Turbine

Iowa Railway and Light Co. Gives Results of Tests of 15-Stage, 3500-kw. Turbine-Generator. By John M. Drabelle

THIS ARTICLE discusses a test of a multi-stage turbine that was run jointly by the seniors of the 1924 classes of Mechanical and Electrical Department of the Iowa Railway and Light Company. The test was run in

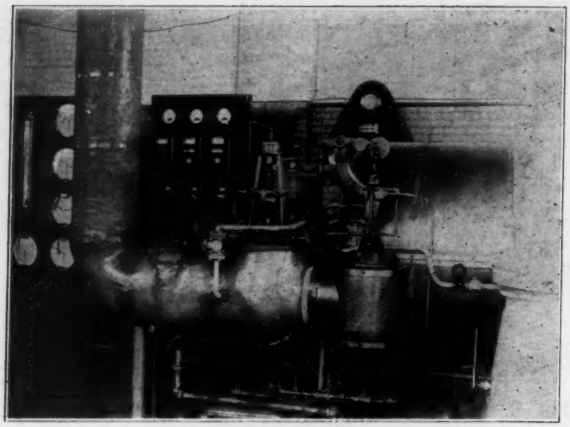


FIG. 1. TURBINE THROTTLE AND GOVERNOR GEAR

accordance with the test codes of the A. S. M. E. and the A. I. E. E. covering this class of apparatus. All instruments and gages used were calibrated both before and after the test.

Manufacturer's guaranties were based on the following standard condition of 225 lb. gage, 100 deg. of superheat and an exhaust pressure of one inch mercury.

Net Load in Kw.	Vacuum		
	1 in.	1½ in.	2 in.
1750	13.3	14.35	14.9 lb. per kw-hr.
2625	12.5	13.5	13.9 lb. per kw-hr.
3500	12.25	13.1	13.5 lb. per kw-hr.

When the rather small size of the unit is considered the rates above are low and mean quite a step in advance in turbine design and a saving of a considerable quantity of coal and money to the Public Utility industry.

The turbine which was manufactured by the General Electric Co. has the following rating: For the generator end, 3600 r.p.m., Form T, 1098 amp. 80 per cent P. F., kw. 3500, cycle 60, volts 2300, and for the steam end 3500 kw., 3600 r.p.m., Form M, 15-stage, 225 lb., 100 deg. superheat.

The condenser is of Worthington manufacture of the surface type, the tube surface is 6250 sq. ft., number of tubes 2345, ¾ in. OD No. 18 Bwg, 14 ft. long. At full load the condenser requires 5000 g.p.m. With this quantity of water passing through the condenser the velocity through the tubes is 4.3 ft. per sec.

TABLE I. WATER RATES SECURED AT VARIOUS LOADS

Kilowatts	Absolute Pressure Inches Hg	Water Rate Obtained	Contract Rate
882	1.0	15.38	None
874	1.5	16.52	None
890	2.0	17.3	None
1047.5	1.0	14.84	None
1025.3	1.5	15.75	None
1010.4	2.0	16.45	None
1753.3	1.0	12.22	13.3
1764.9	1.5	13.68	14.35
1758.2	2.0	14.4	14.9
2655	1.0	12.37	12.5

Circulating, hotwell and air pumps are all motor-driven and accurate measurements of their power input could be made and the results of the performance of the auxiliaries will be described later.

The load runs at the various loads and vacuums were for the period of one hour and sufficient time was allowed between runs for the temperature changes in the turbine to take place.

Output was determined by the two wattmeter method, the instruments receiving their voltage and current from instrument transformers specially calibrated for the test. Direct-current ammeter and voltmeter were used to obtain the input to the field of the turbine.

The determination of condenser leakage was a failure due to the conductivity apparatus giving erroneous results and the test results are not corrected for condenser leakage.

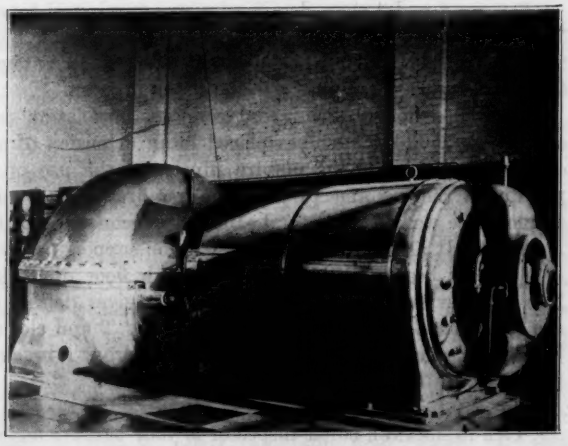


FIG. 2. MULTISTAGE TURBINE UNIT IN BOONE STATION OF IOWA RAILWAY AND LIGHT CO.

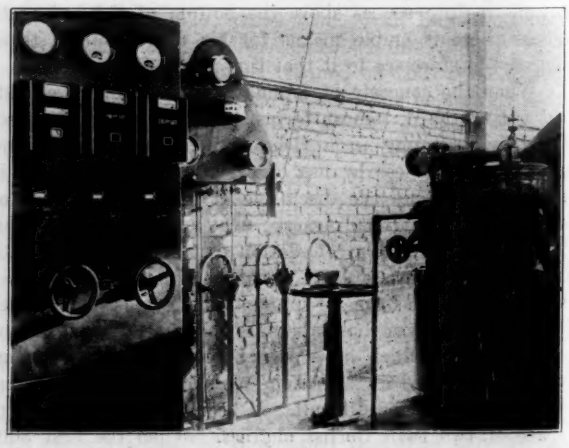


FIG. 3. AUXILIARIES ARE CONTROLLED FROM BOARD NEAR THROTTLE END OF TURBINE

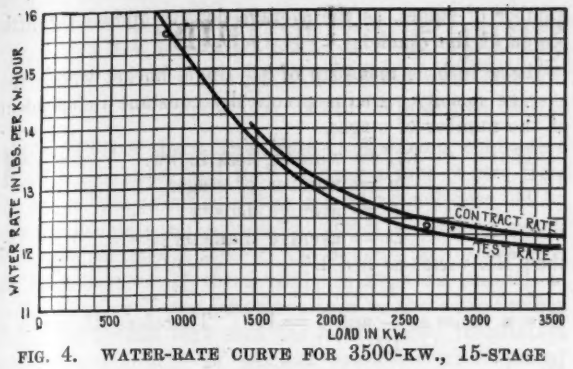


FIG. 4. WATER-RATE CURVE FOR 3500-KW., 15-STAGE TURBINE

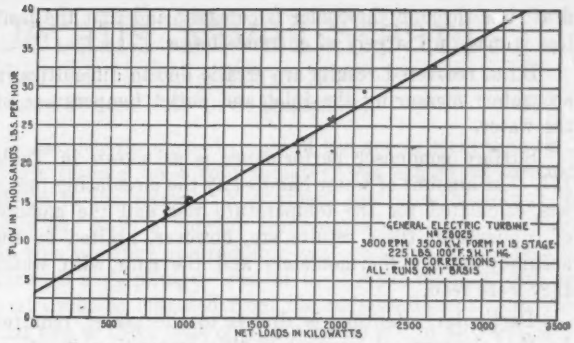

FLOW IN THOUSANDS LBS. PER HOUR
NET LOADS IN KILOWATTS
GENERAL ELECTRIC TURBINE
NK 28025
3600 RPM 3500 KW FORM M 15 STAGE
225 LBS. 100° F S.H. 1" HG.
NO CORRECTIONS
ALL RUNS ON 1" BASIS

FIG. 5. STEAM CONSUMPTION OF TURBINE AT VARIOUS LOADS

In order to vary the vacuum, air was admitted to the exhaust casing of the turbine. The orifice through which the air passed was calibrated and the amount of air known.

The generator is supplied with a surface air cooler through which the ventilating air passes and gives up its heat to the condensate passing through the tubes, thus returning to the boiler plant the generator heat losses.

As a check for daily operation a type M register indicator, recorder Venturi meter is permanently installed. This instrument served as a check on the weighing tanks and for the entire test the meter checked 1.04 per cent low as referred to all weights of water added together and referred to the registered amount in pounds on the meter register.

Test runs were scheduled as follows: No load, quarter load, half load and full load, the full load point could not be run on account of lack of load on the system and the full load value is given from the flow curve. All loads were run at one inch, one and a half inch and two inch absolute pressure.

Figure 1 shows the steam end of the turbine with its throttle and governor gear. Figure 2 shows the generator end of the turbine and the exhaust hood. Figure 3 shows the control panel for the auxiliaries and the watthour meters measuring the input into each.

One week prior to the test the turbine had been washed out with 30 gal. of kerosene on the steam end. No adjustments of any kind were made by either the General Electric Co. or the Worthington Company before or during the test, and the results obtained represent as nearly as possible the day-to-day results of the Boone Station.

On account of lack of load on the system, the 1½ and 2-in. points at 2650 and 3500-kw. points could not be run. With the test data available and by plotting a flow curve the probable water rate at 1 in. and 3500-kw. load is in the neighborhood of 12.1 lb.

The performance of the surface air cooler is shown in Table II and Fig. 6. It will be noticed that the air loss or

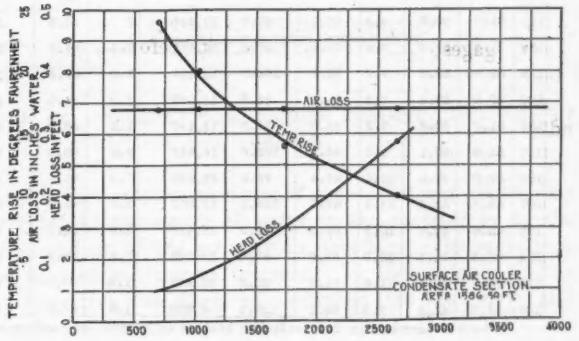


FIG. 6. CURVES SHOWING PERFORMANCE OF SURFACE AIR COOLER

TABLE II. TEST RESULTS OF SURFACE AIR COOLER, CONDENSATE SECTION ONLY

GENERAL ELECTRIC SURFACE AIR COOLER - TWO CONDENSATE AND TWO RAW WATER SECTIONS

Runs No.	Draft Loss in. Water	Head Loss Ft. Water	Air in °F	Air Out °F	Water in °F	Water Out °F	Rise	Flow in lb/hr.	B.t.u. Removed per hr.	Net Load KW	Excitation K.W. at Rings	Ft.lb. per hr. Required
111	.34	1.01	89	118.0	63.6	88.0	24.4	13,567	331,000	882.2	6.42	13,700
113	.36	1.51	88	112.0	66.7	86.0	19.3	14,471	130,000	874.6	7.81	18,980
116	.35	1.62	89	120.0	70.3	90.7	20.4	15,409	315,000	890.4	8.64	25,000
108	.34	1.41	86.5	117.0	64.0	84.0	20.0	15,549	311,000	1047.5	7.84	21,900
109	.34	1.55	88	118.0	66.0	86.0	20.0	16,180	323,700	1025.3	7.93	25,100
110	.34	1.62	89.5	118.5	68.2	87.5	19.3	16,649	324,600	1010.4	7.6	26,990
106	.34	3.37	85.0	117.0	65.4	80	14.6	22,405	327,000	1784.9	10.47	82,400
107	.34	3.57	86	118.5	67.5	81.0	13.5	25,370	342,400	1758.2	9.98	90,600
105	.34	2.83	84	115.0	64.0	78.0	14.0	21,415	300,000	1753.5	9.8	69,200
115	.35	4.16	84	119.0	69.5	81.7	12.2	27,053	330,000	1963.7	9.25	112,500
118	.34	5.74	91.5	124.5	74.2	85	10.8	32,800	355,000	2655.7	9.3	188,300
104	.34	----	105.0	129.0	55.1	118.5	63.4	3,220	204,148	0	5.1	-------

Condensate section 1586 sq. ft.

draft loss through the cooler is constant and that the heat loss is made up largely of entrance losses.

B.t.u. recovered results are erratic due to difficulties in accurately measuring the inlet and outlet temperature of the water.

Surface condenser performance is as shown in Table III. The amount of water handled by the circulating pump was calculated for the temperature rise and the amount of condensate; these results are, however, limited by the accuracy of the thermometers and the care with which they were read.

Particular attention is drawn to the power required by the air removal apparatus, this amounting in steam taken by the main unit of not to exceed 60 lb. per hr.

In conclusion it may be stated that the results from the test were highly gratifying and that the unit and its auxiliaries are exceedingly economical in both steam and power consumption. Such a unit may well be given serious consideration where coal costs are high and the greatest economy must be practiced in operation. In order to account for the efficiency of this design compared with others having a fewer number of stages, the following statement was secured from E. V. Pollard of the General Electric Co.:

TABLE III. RESULTS SECURED DURING TEST OF SURFACE CONDENSER

Run No.	Temp. Water In °F	Temp. Water Out °F	Rise	Hotwell °F	Exhaust °F	Lb. Steam Condensed	Abs. Pres. in. Hg.	Temp. Air to HDV °F	Total head Circulator lb./sq.in.	Total head hotwell lb./sq.in.	RPM Circulating pump	RPM HDV	Water Cir.by Temp. Rise	Power Input Air Pump KW	Power Input Circulating Pump KW	Power Input Hotwell Pump KW
111	51.3	59.3	8.0	63.6	82.7	13,567	1	66.5	23.1	12.0	1030	156	3,240	3.48	55.8	2.44
113	51.3	59.7	8.4	66.7	97.0	14,471	1.5	64.0	23.2	12.6	1002	156	3,270	4.6	56.65	2.54
116	53.75	63.3	9.5	70.3	106.5	15,429	2.0	66.5	19.5	12.5	942	135	3,090	4.6	42.66	2.59
108	50.5	59.4	8.8	64.0	83.7	15,549	1.0	65.0	23.6	12.5	1020	155	3,350	3.46	55.7	2.36
109	51.0	60.3	9.3	66.0	96.0	16,160	1.5	63.8	23.7	12.85	1042	162.5	3,320	4.03	55.8	2.45
110	51.8	61.1	9.3	68.2	105.8	16,649	2.0	65.0	23.5	12.55	1010	154.0	3,400	4.48	56.7	2.59
106	49.0	61.4	12.4	65.4	95.0	22,409	1.5	61.6	24.5	13.5	1056	154.5	3,430	3.84	57.8	2.59
107	49.7	62.6	12.9	67.5	106.5	25,370	2.0	62.4	24.7	13.87	1065	154.5	3,740	4.42	57.5	2.78
105	48.4	59.2	10.8	64.0	85.0	21,415	1.0	61.2	22.9	13.4	1020	148	3,770	3.29	57.6	2.75
115	51.8	64.7	12.9	69.5	97.5	27,055	1.5	65.6	25.8	14.0	1102	159	3,980	4.6	61.7	2.7
118	55.7	69.9	14.2	74.2	82.5	32,877	1.0	69.0	24.6	15.0	1055	156.7	4,360	3.4	69.1	3.3
104	42.0	45.5	3.5	55.1	115.8	3,220	1.0	63.2	23.0	10.95	1000	148	1,748	3.08	51.6	2.36

Note - No correction for condenser leakage on account of failure of leakage apparatus "H" Taken as 950 B.t.u. Area of condenser 6250 sq. ft.

The Reasons for Increase in Turbine Efficiency as Number of Stages is Increased

In order to demonstrate the reasons for an increase in turbine efficiency as the number of stages is increased it is necessary to consider turbines composed of single bucket row wheels of constant diameter. It is assumed also that the operating conditions, steam conditions and revolutions per minute, are fixed.

The following general relations are well known and may be found in any handbook:

"The amount of energy that a turbine wheel can extract at its maximum efficiency varies as the square of the wheel diameter;

"With a given quantity of energy the number of stages required for maximum efficiency varies inversely as the square of the average diameter.

"The windage loss in a given stage varies directly as the density and as the fifth power of the diameter; and the total windage loss of the turbine varies directly as the number of stages, as the average density and as the fifth power of the diameter."

In a turbine made up of all single bucket wheels the average density remains practically constant independent of the number of stages.

If RL = windage loss in kw.
n = number of stages
d = average density
D = average diameter

then RL varies as $n\ d\ D^5$.

Now n varies as $\frac{1}{D^2}$ and d = K Therefore RL varies as

$\frac{D^5}{D^2}$ or D^3

The derivation above shows that the total windage loss varies as the cube of the average diameter.

From the above the following conclusions can be drawn:

The average diameter decreases as the number of stage increases.

The windage loss decreases as the number of stages increase.

And since the turbine efficiency increases as the windage loss decreases, the turbine efficiency is increased as the number of stages is increased.

The constant diameter turbine considered above is modified in practice to have small diameters in the high pressure end where the densities are the greatest. As the pressure and density decrease as the exhaust end is approached, the diameters are increased so that each individual stage is operating at its maximum efficiency.

As the number of stages in a turbine is increased the windage loss is decreased and the turbine efficiency is increased. Except for consideration of stress limitations this is the only reason for increasing the number of stages.

Although this would indicate that increasing the number of stages results in a definite gain, it is necessary that the turbine be properly designed to take advantage of this gain.

It is also to be noted that the effect of increasing the number of stages decreases as the rating of the turbine increases.

Attention to Piping Details Saves Steam

PROPER CONNECTION AND CARE OF TRAPS INCREASES SMALL PLANT EFFICIENCY. EXPANSION BENDS PREVENT LEAKY JOINTS. BY C. C. HERMANN

PLACING A steam boiler in a brick setting, connecting it to a chimney and then running a pipe or two from the boiler to a prime mover or a heating coil does not by any means make an economical steam generating plant. Yet when we inspect some of the present-day installations we often wonder if there really is such an animal as economy. Our better judgment tells us there is; further inspection reveals that even the most chaotic installation has the possibilities of efficient operation when placed under the proper kind of supervision whereby some minor changes may be made.

Frequently the best place to begin these changes is with the piping system. For the most part, the general mix-up in piping is confined to the smaller industries, although I have seen some bad messes even in some of the big plants. In the smaller plant the piping is generally left to the judgment of a plumber and once in a while a steam fitter, so called because he has worked on piping other than house or residence work. If the plant is very small, the one-man job goes along well and seems to serve the purpose; but after a while some additions are badly needed and then the discovery is made that something is radically wrong with the piping system. Steam just does not seem to get to those new coils placed at the end of the old line or trouble is experienced with the returns, often resulting in wasting the return to some drain connection. A radiator fills with condensate and on a cold night freezes, costing the price of several pipe fitters for several days to repair it.

One example comes to mind in which the return from one radiator was connected to the live steam pipe of a second radiator. Figure 1 shows the connection as I found it. The heating coil 1 is supplied with live steam through the pipe 2 from the main not shown. The condensate from this radiator is trapped by the trap 3 to the pipe 4 which is connected to the lower pipe 4 of the heating coil 5. The heating coil 1 happened to be on the second floor of the factory and the heating coil 5 on the first floor. The trap 6 on the coil 5 trapped the condensate of this coil to a return 7 at the opposite end of the coil. The pipe fitter who installed this job forgot the basic principle of steam traps of the diaphragm type because he connected the return side of trap 3 to a live steam source in the radiator 5 instead of running his return pipe 8 from trap 3 to some point beyond the trap 6. As a consequence the live steam in the radiator 5 backed up the pipe 8 and held the trap 3 closed continually against the condensate in the radiator 1 except, of course, when the condensate in the lower pipe 4 of the radiator 5 filled up beyond the connection of return pipe 8 to this pipe. The result was that the radiator 1 filled with condensate and was not available as a heating unit. To cure this trouble, the return 8 was connected beyond the trap 6 as suggested above. The men affected by radiator 1 were happy ever after.

This is only one of the many kinks one runs into in the heating systems of the smaller plant. To the experienced man this error in pipe connections probably looks foolish, yet I do not doubt that there are thousands of radiators in service at the present time in as many small industrial plants that fail to heat due to just such foolish connections.

Another instance of trouble I ran across some time ago, while tracing up a cold radiator, was caused by exhaust steam in the return. Now steam gets into the return in only one way: a blowing trap somewhere along the line. In this instance, the radiator was connected to the return through a diaphragm trap in the proper manner, but no heat could be obtained from the radiator except from the first two or three coils of pipe. Steam got in all right, but the condensate could not get out. After removing the cover from the steam trap on the radiator the rouble was easily ascertained. I found the leaky trap fully 200 ft. farther along the return. The steam had filled the return up to the trap and held the trap closed against the outlet of the radiator condensate.

I could enumerate many other cases such as this that cause no end of trouble for the small plant, all affecting the economy of steam generation to a considerable extent.

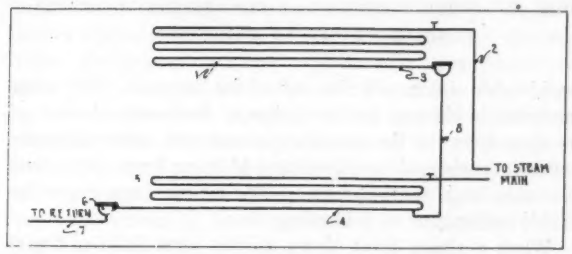


FIG. 1. INCORRECT CONNECTIONS PREVENT OPERATION OF TRAP 3

In the first case the economy of generation was appreciably affected by the excess of water in the radiator or by the dead-ending of the radiator in question. The same may be said of the second instance. In the instance of the blowing trap the steam was escaping into the return and condensing in the hot well.

This is the most serious case of loss imaginable. Take, for example, steam used for heating, at 20 lb. gage pressure. In this case no engine was available, so live steam for heating was being taken direct from the low pressure boiler. The steam lost through the trap we will admit escaped at atmospheric pressure. Comparing the heat units in the steam at atmospheric pressure with that at 20 lb. gage, we note that the latter contains about 16 more B.t.u. In other words, the total heat removed from the steam and utilized in heating was 16 B.t.u., whereas the heat available in the steam was, after deducting the heat in the water, 938.9 B.t.u. Just 1.7 per cent of the heat available was being used for heating purposes. The rest went to heat up the return pipes and the return water.

SELECTING BEST TYPE OF GASKET

Steam-generating economy is influenced by other conditions of piping that will prove valuable in the present discussion. The first condition is leaky joints. Steam lost through leaky joints condenses in the atmosphere and is lost. Not even the condensate may be saved. The vapor rises above the joint and condenses and the water falls to the ground or other surface. A blowing trap may be hard to locate at times; a leaky joint, however, is so apparent that it is surprising how many such joints may be found

in the average factory at almost any time. The practical way to find a blowing trap is to place the hand on the return a few feet away from the trap. The high temperature of the return is invariably due to a blowing trap. A leaky joint, however, makes itself known by a vapor rising above the joint. If the piping is located in a tunnel or basement, the leaky joint makes itself manifest by vapor rising out of the tunnel through manholes or crevices in the tunnel construction.

If the return is discharging in a hot well and there happens to be a blowing trap somewhere along the line,

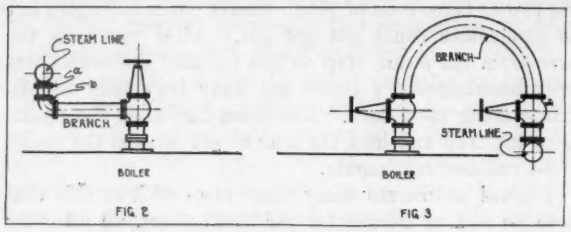


FIG. 2. INCORRECT CONNECTION OF BOILER TO HEADER
FIG. 3. CORRECT METHOD OF CONNECTING BOILER TO HEADER TAKES UP EXPANSION

considerable steam will rise out of the hot well. The same argument holds true in the ordinary feed water heater of the open type; in the closed type, however, some difficulty may be experienced in detecting a blowing trap. An unaccountable high temperature of the return lines is an infallible indication of a blowing trap.

When a steam joint blows, as the term is in ordinary steam-fitting jargon, the packing between the flanges has failed or at least a part of it has deteriorated until it will not stand the pressure exerted upon it from within. The only remedy is of course to replace the packing. At this point I want to sound a word of warning. Before trying to tighten a leaky joint by pulling up the bolts, shut off the steam on the line. It is extremely dangerous to pull up on the bolts with the steam pressure on the line, as a bolt is likely to rupture and the workman is taking a big chance with the joint.

There are several ways to remove old gaskets from a joint but the proper and quickest way is to break the flange bolts, if they are rusted very badly and new flange bolts are at hand. Otherwise, soak the bolts with kerosene and, after removing the bolts, place them in kerosene to remove the rust. Placing a sledge beneath the nut and striking the opposite side a firm blow or two with a lighter hammer often assists in loosening the nut.

Many steam fitters prefer gaskets having an outside diameter slightly smaller than the inside diameter of the bolt circle, as this facilitates the removal of a gasket and the insertion of a new one without removing all the bolts. This type of gasket fits inside the bolts and it is necessary to remove only the bolts on the top half of the joint and to loosen the remainder. It is essential, however, in using this type of gasket, to pull the flange bolts up evenly all around, otherwise the joint will not be tight. One side may take a closer bearing than the opposite side, resulting in a leak when the steam is turned on. When turning the steam on a new joint it should be turned on gradually in order to warm up the joint before the full steam pressure is placed upon it. A new gasket may blow if the full pressure is placed upon it while cold. Another good rule to follow is to turn on sufficient steam to warm up the joint and then turn the steam off again. Thereupon pull up the flange bolts again, as they can be tightened more after warming.

In many of the smaller plants the old style cast-iron piping is quite common and these pipes generally are not provided with turned flanges. Wherever these are met, a somewhat thicker gasket must be used. The gasket should be pliable and capable of being formed somewhat by the flange surface of the joint.

In my judgment, the best kind of a gasket is the ready-made kind. A gasket built up on the job out of rubber and cloth is not worth the labor of making, let alone of placing in the joint. The real cost of this type of repairs to a steam line is in the placing of the new gasket and it has been my experience that poor, cheap gaskets do not pay in the long run.

Before leaving this matter of joint repair I want to call attention to the method of opening up the joint to

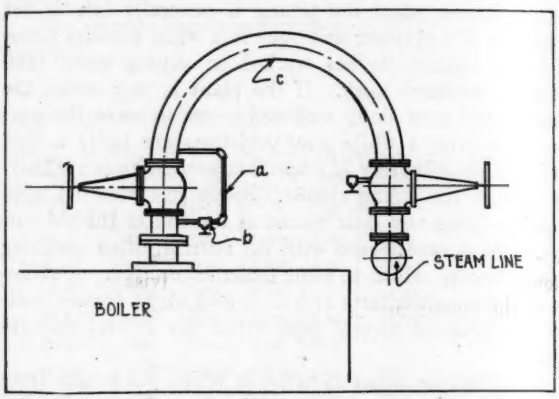


FIG. 4. PROPER BYPASS ON VALVE ENABLES IT TO BE DRAINED

make a repair. I recall having seen a nice 12-in. flange broken in two pieces some time ago just on account of the inexperience of the workman in opening up the joint. The workman drove a chisel between the flanges on one side only; the result was a broken flange. For this purpose three chisels should be provided, having somewhat slender ends. These should be driven between the flanges equally spaced around it and with equal pressure. It is necessary to open the joint only slightly, just enough to remove the old gasket, scrape the joint and put the new one in. There is really no occasion to drive the chisel in very deeply.

Proper Boiler Connections Are Important

Second in the array of points affecting the economical production of steam is the consideration of pipe bends. Here also we find a trouble that is unusually common to the smaller plants, primarily due to an attempt at economizing in the initial installation. Expansion and contraction are the principal forces existing in the universe. Increase in temperature is invariably accompanied by expansion of the materials in which the increase takes place; likewise a decrease in temperature is accompanied by a contraction of the materials.

Expansive and contractive forces of the boiler shell are assumed to have been taken care of, but it is surprising that we find piping installations directly on the boiler

wherein these forces are, in a great measure, ignored. The most common boiler connection to which I refer is that shown in Fig. 2. It is generally reasoned that since the branch pipe connects to the steam line by a right angle ell, the expansion and contraction has been taken care of. This is only partially true. The section of piping directly under the steam line can come and go; but, in doing so, considerable stress is thrown on the flange bolts at "a" and "b". A rupture may occur. The correct connection for this place is shown in Fig. 3. A comparison of these two figures shows the faulty construction of the installation of Fig. 2 without further comment.

We should not leave this subject without some comment upon the type of valve that should be recommended between the branch and the boiler, as well as on the end of the branch next to the main. Globe and angle valves for these places are poorly suited, primarily due to the rapidity of their opening and the liability of some careless pipe fitter placing the valve in the line so that when it is shut the pressure is against the stem. Notwithstanding the more common use of globe and angle valves for these positions, the gate valve is to be recommended because of its more gradual opening for a given turn of the hand wheel. There is less danger from broken connections due to water hammer when the gate valve is used. The connection shown in Fig. 3 insures against condensation pockets, unless the valve next to the main is left open with other boilers on the line. In this case the bend may be drained by the small connection ahead of the valve. The valve on the steam end of the bend may be eliminated; however, it is generally conceded to be advisable to include it in the installation.

Considerable difference of opinion exists regarding the way a boiler should be turned on the line where other boilers are on the line with a full head of steam. My individual practice has always favored having the pressure within the boiler to be placed on the line at about the same steam pressure as that of the line. In this way there will be very little velocity from one point to another and any condensate momentarily formed in the branch, due to the lower temperature of the branch, will return by gravity either to the boiler or to the main. Suppose for the moment that the boiler is placed on the line with a pressure below that of the line. In this case the steam from the line will rush towards the boiler, unless the latter has been equipped with a non-return valve, which, by the way, should always be the case. The chief difficulty with the gate valve for this purpose is that it is not provided with the safety feature found in the non-return valve and that it is hard to close tightly.

Figure 4 shows how a boiler may be safely opened on the line by means of a small bypass as shown at "a". The valve "b" on the bypass is first opened allowing steam to fill the branch pipe bend "c", thereby heating up this branch and bringing its pressure up to that in the boiler before opening the main valve. After opening the main valve, the bypass is closed. With this arrangement the valve "d" is opened first after the branch has been heated up and its pressure is equal to that in the boiler. Any condensate in the branch is drained off by a drain in the body of each valve. The bypass is a protection to the large valve as cases are not infrequent in which the main valve has been broken at the time the boiler was placed on the line.

How the Management Causes Low Efficiency

A Really Hard Power-Plant Job is to Get Improvements Necessary for Economy. By B. F. Goldin

WHAT seems to be the hardest thing I have to do in power plants is to get the owner, the manager or the head of the company to save their own money. That is strange isn't it? If this man were out in deep water and couldn't swim and some one threw him a rope he would catch hold of it, if he lost his pocket book and it was returned to him he would take it, but when you try to get him to save his own money by saving his fuel he stops. I started out with a very large corporation that handles milk, both raw milk and preserved milk, with many plants scattered throughout the country. In the plant with which I am connected at present one would find the men lined up in about the usual way in the power house. Here we have the coal passer, a fireman or two, the assistant engineer, and the chief. My reason for naming these gentlemen in this order will be seen when I state that one of our superintendents in writing an article for the company paper stated that things should be so and so from the fireman to the superintendent.

Red Tape Hard to Untie

But about that big corporation, ours is so large that it is impossible to find the boss who really decides all main questions. I go to the chief about some project whereby the company would be able to save some money. Well, the chief is up against it, too, for he has to go further up. I go hunt up the assistant superintendent; he agrees perfectly with my statements, passes me up to the real big boy as one would suppose. He says it's a good idea and he will see what he can do with the main office. Then there is a long lapse of time, lots of correspondence and red tape to go through with; probably the architect has to work for some time on a blue print and generally it is a good long time before we even hear any more about it.

Well, some time we get a little notice and get something done if we make noise enough, but more times it fades away and they keep right on wasting their fuel and heat energy. I don't own this plant, but have become interested in this work and want to give the best I have in work and knowledge if it is possible to persuade the company to take it.

Where to Look for Losses

Only a small percentage of the original potential energy contained in the fuel ever gets to do actual work at the machine in furnishing a product but where is it wasted? Surely one can find some of the places in any plant and stop them.

Here is where we can look for these wastes after the coal is delivered: handling at the plant, some is wasted in the ash, by radiation, by incomplete combustion, or on account of excess air, loss due to soot on the heating surface of boiler, or scale in boiler, loss by steam and water leaks, wasting of engine exhaust, loss by friction and trans-

mission and if one is looking for places whereby fuel is wasted they can generally be found in plenty.

There is a nice looking coal pile out there; it probably was unloaded with an elevator, carried up some 30 or 40 ft. and dumped. We have a nice cone shaped pile with all of the fine poor coal in the center and the large pieces and coarse coal all around the outside. Now, it took only a few minutes to change that coal from the car to the pile by this method but the company pays dear for that few minutes.

When this coal is delivered to the fireman he gets a fine, poor coal one day and the next day he gets nice, coarse, free-burning coal. What showing can he make towards efficiency? The grates cannot be changed every day, but his method of handling must be changed; where, if the coal was kept mixed thoroughly throughout the pile when unloading the fireman can feel his way, get his load, his draft and depth of fire and bring his work up to standard of efficiency by using a gas analyzer to check up the CO_2 percentage.

Now, if the manager could be persuaded to buy a few instrument such as a gas analyzer, draft gages, pyrometers, a flow meter or a water meter we would be in good position to find out where some of the losses are that are taking his money. We could stop them and use the money to pay for these instruments, make the boys who are doing the work some better off financially and put the rest in the company's treasury.

Losses in the Engine Room

Now let's go into the engine room and see the chief. We have a right to expect to meet a man who understands machinery, one who keeps his power generating units in efficient condition so as to use the steam that we have just made in a way to get the most mechanical energy out of it but we have to take this fellow as we find him.

For instance that big turbo-generator is carrying only a small fraction of the load it was made for. Do you suppose the power factor is very big in per cent? Over in that corner is a big Corliss engine, probably 100 hp., doing nothing but pulling a line shaft and probably the valves haven't been set since it was assembled. That large pump over on that side needs new packing all around to stop the steam blowing out, those iron washers that the chief put in to take up the lost motion of the valves ought to come out and the valves should be properly set and those traps that are leaking ought to be repaired. Of course it is likely that all these things will not be found all in one engine room but sometimes its equal is found and I suppose the chief could be asked to remedy these, cut out the extra engine, bring the power factor up, make a better engineer of himself, stop our exhaust steam waste, make the fireman's work easier and save money for the company.

You see there is not much of the exhaust steam used; of course some of it is used for heating the feed water but there is a large amount going to waste and if the manager would give us that exhaust heating system for the factory wouldn't we save a nice roll next winter? But I suppose a set of return dump traps would cost something so Mr. Fireman and Mr. Engineer, you will have to turn on the live steam and burn some more good coal.

Out in the factory in different processes where heat is required one could no doubt find places where the exhaust steam could be used to advantage. We step into different departments and see many wastes such as motors running where no work is being done, here is a number of lights turned on in rooms where no one is using them, we find radiators red hot and the windows wide open and so one can go on finding these things but where is the boss? He is either in the office or in the shipping room busy figuring up how big a shipment he is going to forward today or tomorrow. Doesn't he realize that he will have to send a little extra this time to pay for the things we have found through his factory? He is not an engineer, however, and doesn't understand and probably doubts whether we do or not so by this time we get back to the fire room, the stoker boy has heard the verdict, he is some discouraged and is sitting on a box or nail keg taking things easy, for he was just down there and filled the old furnace up full of coal that will last quite a while and as long as the hand on the steam gage stands straight up and down he knows that no one will bother him and so the waste goes on.

Probably about all that can be done is to keep our eyes and ears open, get sharpened up on that grindstone for some day, some time we each will meet with a man who will require good engineering, he will place us right and put us in a position to progress if we are ready and really know things. He will take good ideas and profit by them, then worth will be the determining factor, the company will save money. Let's shake his hand.

The Story of Power Told in Motion Pictures

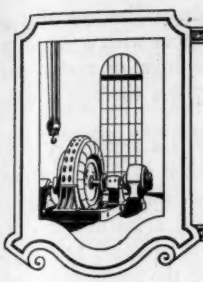
A three reel motion picture entitled Power has been produced by Stone & Webster, Inc., which tells the story of the growth in the use of steam power from the first crude piston engine to the steam turbines of the present day.

Animated drawings have been used profusely throughout the film to show such things as the operation of a steam turbine, just how alternating current is generated, etc. By means of such drawings the location and relative importance of water power is compared with the coal deposits of the United States and a Chinese wall of coal builds itself completely around the United States to illustrate the tremendous quantity of coal mined each year.

The latter part of the film is devoted to actual construction scenes of a large central power station and ends with an animated chart which indicates that we are just upon the threshold of a period of remarkable power development, which in the next seven years will duplicate all of the central station capacity of the last forty years.

Showing of the three reels takes about 45 min. Bookings may be had without rental fee for engineering meetings by applying to Stone & Webster, Inc., 147 Milk St., Boston, Mass.

The Bureau of Mines recently completed a survey of the ash content of anthracite coal from dealers' yards in Massachusetts. The object of this work was to determine the average ash content and the variation of ash in anthracite in some easily described area, to demonstrate standard sampling methods, and to learn something of the feasibility of itinerant coal sampling. Massachusetts was selected because it is easily visited, and because it has a coal-quality law. The average ash content of the different sizes ranged from 13.2 to 19 per cent.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Voltage Regulation in Industrial Power Plants

A Description of Methods and Devices Used to Maintain Constant Voltage on A.C. and D.C. Systems. By Victor H. Todd

THERE WAS a time when the voltage of a power plant was considered to be regulated in a satisfactory manner if the switchboard attendant occasionally looked at the voltmeter and gave the generator field rheostat a twist or two to bring the voltage within a few volts of the normal value. This day is over, however, as the deleterious effects of even slightly high or low running voltages have been recognized, and automatic devices perfected to eliminate the personal element and maintain constant voltage every instant, night and day, regardless of changes in load or other conditions which might tend to change the voltage.

One of the first bad conditions caused by the irregular voltage of a generator is the effect on the lighting system throughout the whole plant supplied. The electric lamps are all designed to be operated at a certain voltage at which point many exhaustive and expensive tests have determined that they are most efficient in candlepower and life. If the voltage goes lower, the candlepower efficiency goes considerably lower, while if the voltage goes higher, the life is considerably shortened.

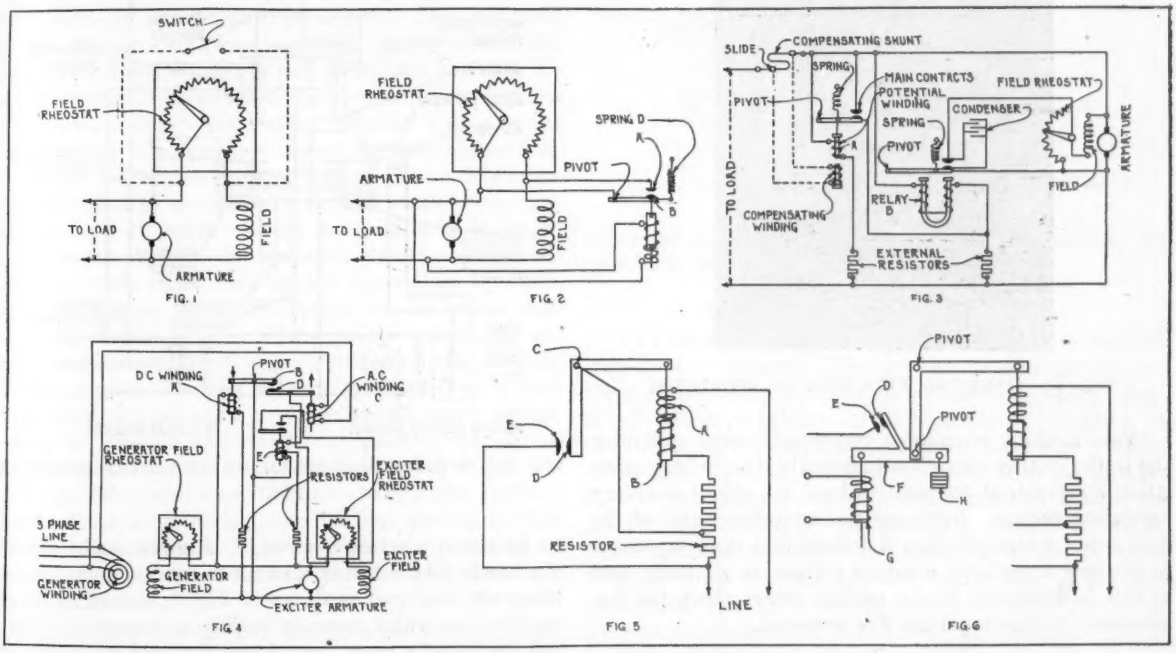


FIG. 1. ELEMENTARY DIAGRAM OF A GENERATOR WITH PROVISION FOR SHORT CIRCUITING THE FIELDS. FIG. 2. ELEMENTARY DIAGRAM OF A GENERATOR WITH A D.C. REGULATOR. FIG 3. TYPICAL DIAGRAM OF A D.C. VOLTAGE REGULATOR. FIG. 4. ELEMENTARY DIAGRAM OF VOLTAGE REGULATOR WITH D.C. AND A.C. ELECTROMAGNETS. FIG. 5. DIAGRAM OF A.C. VIBRATING ELEMENT. FIG. 6. VIBRATING VOLTAGE REGULATOR PROVIDED WITH A.C. CONTROL ELEMENT

If heating devices are used, the heat will vary as the square of the voltage, giving insufficient heat on low voltages and a tendency to short life on high voltages. Motors, too, are affected by voltage variations, tending to run slow and develop insufficient power on low voltages, and to run fast and overheat on high voltages.

Transformer losses also vary according to the voltage applied and may increase considerably with increased voltage, thereby resulting in decreased capacity and increased expense of operation. And synchronous apparatus, while not affected in speed, will change in power factor on voltage variation with a resulting loss in reactive (wattless) current and varying pullout torques.

The first d.c. generators were plain shunt wound machines and as they were loaded up, the voltage developed dropped off unless the field rheostat were readjusted. To overcome this, an additional winding was placed on the field poles and the load current passed through it, so that with increased load, more magnetism was developed and the normal voltage approximately maintained. In fact, by increasing these series field turns, it is possible to have the generator voltage rise with increased load, giving an additional compensation for line drop to a given point and keeping the voltage constant at a certain center of distribution.

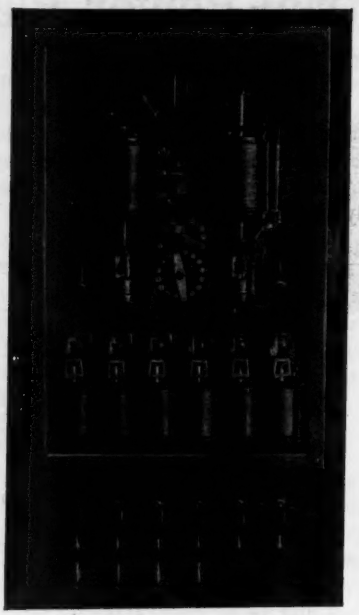


FIG. 7. VIBRATING TYPE VOLTAGE REGULATOR

This machine is called a compound wound generator and in the smaller sizes gives sufficiently close voltage regulation for practical purposes without the aid of auxiliary regulating devices. But since the saturation curve of the field is not a straight line, it follows that it is impossible to produce a perfectly constant voltage at all loads, and as this is demanded in the modern power plant, the d.c. automatic voltage regulator was perfected.

The D.C. Automatic Voltage Regulator

In a simple d.c. generator, the connections may be as shown in Fig. 1, where an armature is shown feeding a line and also its field in series with a suitable rheostat. Now assume that the field rheostat is set to generate, say, 75 v. on the armature. Now with a single-pole switch, as shown by the dotted line, short circuit the field rheostat. The voltage will immediately start rising and if the switch were allowed to remain closed might build up to perhaps 125 or 150 v., depending on the characteristics of the machine. But suppose that at the instant it reaches 110 v. we quickly open the switch. The rheostat is again in and the voltage tends to fall. But suppose again that when it drops to 109 v. we close the switch and bring it up to 110 and then open until it falls to 109; then close again and repeat this cycle indefinitely. The result would be that the voltage would be maintained between 109 and 110 v. regardless of the load and while it could be done only very crudely by hand as in the foregoing illustration, yet this is exactly what the automatic regulator does with a rapidity of about 600 or 700 closings and openings, or cycles, per minute, so that for all practical purposes there is a constant voltage maintained.

To illustrate this, in Fig. 2 there is a stationary contact A, and a moving contact B attached to a lever which carries an iron core working under the influence of a solenoid, which in turn is connected to the armature or line. Normally the weight of the armature is balanced by a suitable spring D which also tends to keep the contacts closed. At the beginning of the cycle, the contacts of this relay short-circuit the field rheostat, thus causing the armature voltage to start building up. As it does, it increases the pull on solenoid C, which finally reaches a point where it pulls the contacts open. This cuts in the rheostat and the voltage begins to fall, thus lessening the pull on C and allowing the spring to close the contacts again, repeating this and maintaining constant voltage as long as the regulator is in operation.

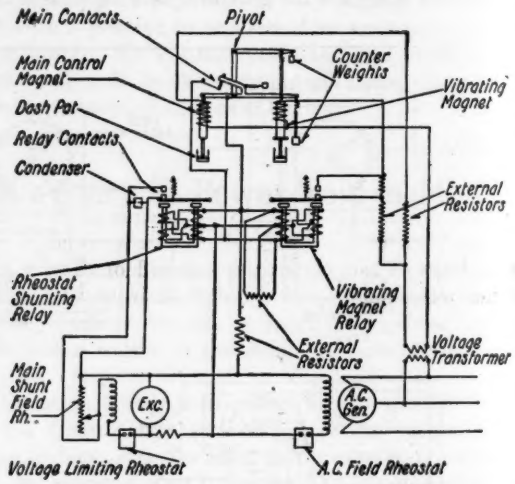


FIG. 8. SCHEMATIC DIAGRAM OF REGULATOR SHOWN IN FIG. 7

In actual practice, however, it is impractical to handle the heavy field currents through a delicate relay, so two relays are employed as shown in Fig. 3, one an extremely sensitive one which responds quickly to changes in voltage and the other a more rugged one designed to handle the heavy field currents. As shown in Fig. 3, the main relay A is energized from the line, and its contacts energize or de-energize the relay magnet B, whose contacts in turn short-circuit the generator field rheostat. This relay is sometimes wound with a differential or main-and-neutralizing winding. In this, the main winding is continually energized and keeps the contacts open and when the main relay closes its contacts it energizes the neutralizing winding which kills the relay magnetism and allows the contacts to close.

In addition, the main relay may be provided with an additional winding so that the voltage maintained will rise with increase of load, thus compensating for line drop to the center of distribution. This winding is supplied from the drop of a shunt which carries the main line current and its effect is to neutralize the magnetism in the main relay magnet and decrease its pull slightly, thereby allowing the line voltage to rise to a somewhat higher

value before the contacts open and remove the "short" on the generator field rheostat.

In actual practice, there is a static condenser connected across each set of contacts to absorb the energy or "kick" each time the contacts open and prevent a destructive arc at the contacts. Too great capacity is to be avoided, however, as when the contacts close again the discharge current rushing from the condenser tends to weld the contacts together and this itself is objectionable if the condenser is too large. Most modern regulators, including the following ones, are provided with reversing switches to reverse the polarity of the contacts and cause more even wear.

Regulators for A.C. Generators

Following the practice of d.c. compound wound machines, attempt was made in a.c. machines to maintain constant voltage by building them with inherent close regulation and rectifying the load current, forcing it through a series field winding. The resulting designs were impractical, as it was difficult to brace the windings against the stresses of short circuits. They soon gave way to the automatic relay regulated type in which the generators had exceedingly poor inherent regulation. The early ones, and the smaller sizes, were regulated similar to the d.c. method just described with a pair of contacts shorting the field rheostat and the solenoid which opened these contacts when normal voltage was reached supplied from the a.c. line. But as the generator capacities went higher and higher, the field currents became so great that it was no longer practical to control them through a short circuiting relay or bank of relays. As all the field of these larger machines was supplied by separately driven exciters, attempt was made to regulate the a.c. line voltage by working on the exciter field. This failed for the reason that due to the high inductance of the generator field, the exciter voltage was allowed to go higher than was actually required to produce correct field excitation of the a.c. generator and then when the a.c. voltage built up high enough to open the contacts and remove the short on the exciter field, and even after the exciter voltage started to fall, yet due to the field inductance, the field current still kept increasing for a short period, thus making the a.c. voltage still rise above normal. This resulted in a pumping or "seesawing" of voltage above and below normal, which was very objectionable.

To overcome this the d.c. control relay was combined with the a.c. regulating relay to form the modern regulator often spoken of as the "Tirrill Regulator." The diagram in Fig. 4 shows the first successful type of this regulator where the solenoid A connected to the exciter bus tends to pull its core downward and open contacts at B. The a.c. solenoid C is connected to the a.c. line through suitable transformers, and tends to raise its plunger and also open contacts at D. The cycle of operation is as follows, starting with no voltages: The exciter built up its voltage and excites the main generator field and also solenoid A. The main generator now builds up voltage which energizes solenoid C. When the exciter voltage raises to a certain amount, solenoid A pulls contact B away from D and this opens the neutralizing winding of relay E which immediately pulls its contacts open and opens the short on the exciter field. The exciter voltage now starts to fall, and contacts B and D would close but due to the main generator field inductance, the a.c. voltage is still increasing slightly to its proper amount and solenoid C makes contact D go lower. This allows the exciter voltage to fall lower than it would otherwise in order that a quick restoral would not push the a.c. voltage still higher. After a few oscillations, the vibrations of the solenoid A settle down to a uniform rate, the contacts B and D, and the contacts of E opening and closing several times per second, the exact rate and time of closure depending on the position of contact D and plunger in solenoid C. If a load comes on the generator, thus calling for a different d.c. exciter voltage, the plunger of the a.c. solenoid shifts its position slightly to vary the position of contacts B and C. In practice, it must only shift its position about $\frac{1}{32}$ in. to cover the entire range in exciter voltage. For larger installation, additional field rheostat shunting relays are

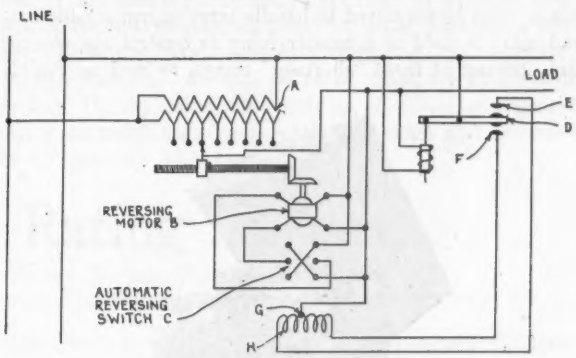


FIG. 9. DIAGRAM OF STEP BY STEP FEEDER REGULATOR

connected in parallel to handle the larger currents, the rule being to allow about 2 amp. per relay.

Later Model Tirrill Regulator

In a later model regulator, the d.c. solenoid is replaced with an a.c. vibrating solenoid which in conjunction with the a.c. measuring solenoid forms the basis of an unexcelled voltage regulator. The principle of operation of this vibrating solenoid may be learned from Fig. 5 where the solenoid A when energized tends to raise the plunger B, thus producing a counterclockwise rotation around the pivot C which tends to open the main contacts D and E. These contacts normally short-circuit a section of resistance in series with the solenoid, and as soon as the contacts open, this extra section is cut in, thus decreasing the pull on the solenoid A and allowing contacts D and E to close, with the cycle repeating itself continually, with a definite time period of operation.

In order to regulate the length of time that the contacts are closed in order to regulate the voltage, it is necessary that the position of contact E be changed proportional to the voltage. One method of doing this is to provide an additional arm F, as in Fig. 6 with a plunger G, and a counterweight H. This arm is pivoted as shown and carries the floating contact. Now, when the a.c. line voltage is low, the plunger G is low and contacts D and E are in contact. In this case solenoid A must take a longer time to raise the plunger and open the contacts, which actually means that they open the "short" on the field rheostat. This allows the a.c. voltage time to build up, and since the vibrating element is continually functioning to open and close the short on the field rheostats it gives the generator sufficient time to attain its full voltage without excessive exciter voltage ordinarily caused by the main field inductance and thereby prevents "hunting." Thus,

for every condition from no load to full load, there is a definite position of the contacts and a definite rate and time of closing or effective resistance of contacts due to these positions causing an average field strength which results in a definitely regulated voltage. Should any change occur, this voltage is brought back to normal quicker than by any other method.

Figure 7 shows a typical regulator of this type and Fig. 8 shows its diagram of connections to a single generator and exciter. It will be noted that when the main contact closes it closes the de-energizing winding to two relays, causing them to also close their contacts. One relay is used to close the short across the resistor in the vibrating magnet circuit while the other is used to short the exciter field rheostat. When a number of "shorting" relays must be employed to handle large currents, this second relay is used as a master relay to control the closing and opening of these "shorting" relays, as well as the vibrating relay. The number of relays may be determined approximately by measuring the maximum field current of the exciter and dividing by 5, thus allowing 5 amp. per relay. A 1 microfarad condenser should be provided for each relay. These regulators are suitable for the control of the largest units operated in parallel, with exciters worked either singly or parallel. The exciters must have certain characteristics or adjustments before successful operation can be obtained. They must be able to build up their voltage from residual to normal in about 5 or 6 sec. and fall off in the same time; they must be able to develop from 10 to 15 per cent more voltage than that required by the generator fields with the generator under full load at 80 per cent power factor. Exciters in parallel should have the same characteristics and divide the load correctly no matter at what point on the saturation curve they are worked. There are so many other precautions to be taken that they cannot be even enumerated here, but it should be noted that the greatest troubles caused by incorrect operation are due to mistakes in the original installation and that once a regulator is correctly installed and the rheostats correctly adjusted, it is about as foolproof and perfect a piece of electric apparatus as there is made.

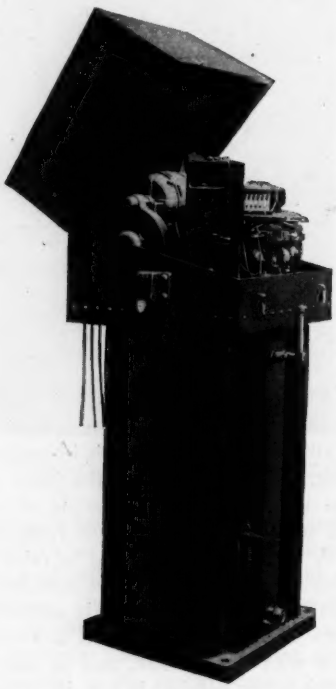


FIG. 10. OUTDOOR TYPE OF FEEDER INDUCTION REGULATOR

Overvoltage Protection

One condition in power plant operation against which additional protection must be provided occurs when a short or heavy load causes low voltage and is suddenly removed. During the "short" the a.c. voltage drops low and the regulator causes the exciter voltage to rise higher and higher in an effort to bring up the a.c. voltage. Then when the "short" is suddenly removed, this high exciter voltage suddenly raises the a.c. voltage to an excessive amount before the regulator can regain control. The remedy is to provide an undervoltage circuit opening a.c. relay and a d.c. voltage regulating relay with their contacts in parallel across a separate exciter field rheostat. When the voltage falls, due to excessive load, the undervoltage relay opens its contacts, thereby giving control to the d.c. relay. The exciter voltage rises to a value ordinarily used to produce full a.c. voltage and then the contacts open, thus cutting the extra field rheostat into circuit. The exciter voltage now falls and the contacts close, continuing this cycle until the overload disappears when the exciter voltage produces proper a.c. voltage, whereupon the undervoltage relay closes its contacts and returns the control to the proper regulator.

Dial Type Regulators

Other regulators which deserve mention at this point are the dial type with the field rheostat moved both by the Thury System and by small geared motors. In the Thury type, there is a reciprocating arm which is provided with two dogs capable of working on a ratchet wheel on the main rheostat handle, either in the generator or exciter field. On normal voltage, neither dog engages but on low voltage, a solenoid allows one dog to engage and the reciprocating motion turns the field rheostat step by step until enough resistance is cut out to bring the voltage to normal; while on high voltage the other dog engages and cuts in resistance.

In the motor operated type, a contact making voltmeter on the a.c. line closes one contact on low voltage and another on high, and these in turn close a reversing switch connected to a small geared motor on the field rheostat, thus turning it to cut in or cut out resistance until the contact making voltmeter "floats" or opens its contacts and the motor stops. These regulators are much slower in voltage recovery than the Tirrill regulators.

Feeder Regulators

Even with a perfectly steady voltage maintained at the busbar or the center of distribution, there are often long runs which may have low voltages at their ends. In some cases, as for example a building located at some distance from the power plant, it might be possible to figure the drop of the line and obtain lamps to correspond. That is, if the line voltage were 120 v. and there was 15 v. line drop at full load, then 105 v. lamps could be supplied. The trouble is that if the load were only half on, then there would be about 112½ v. and the lamps would be overloaded. To overcome this trouble each feeder may be provided with a feeder regulator. For d.c. this would mean a small motor generator booster set, the use of which is

very limited, or a rheostat which is extremely uneconomical. But on a.c. the step by step transformer or the induction regulator may be used. Both are usually actuated by a contact making voltmeter or "primary" relay, while the transformer dial or regulator is moved by the Thury system or a small reversible motor.

Figure 9 shows the scheme of buckboost transformer connections. There is a transformer A whose primary is connected to the line and whose secondary usually of 10 per cent line voltage is connected in series with the load. This secondary has a number of taps which are connected to a dial and dial arm which is operated by the reversing motor B and automatic reversing switch. The contacting voltmeter D closes either one of two contacts E or F, which in turn energizes the closing coils G or H of the automatic reversing switch, which in turn causes the contact arm to move to the right or left and cut in or cut out voltage until the line voltage floats the contacts of D.

The greatest fault of this system is that the contacts on the secondary must not be "dead" shorted by the arm and many ingenious schemes have been resorted to, to overcome this, such as snapping contacts for quick change, arcing contacts to insert resistance and the split arm of the Stillwell Regulator, but none have been as successful as the induction regulator.

The Induction Regulator

This piece of apparatus is in reality an induction motor with a wound rotor and 100 per cent slip. The field or stator is connected across the line and the armature or "rotor" connected in series with the load. It will readily be seen that with a single-phase primary and single-phase secondary, when the full flux passes through the secondary, there is a maximum voltage generated in it in, say, the boost direction, while if the armature be rotated through 180 deg., then there will be the same voltage generated but in the bucking direction. Halfway in between there will be no voltage generated and for other positions a voltage will be generated to buck or boost the line, depending on the position. As will be noted from the illustration in Fig. 10, the induction regulator is driven by a geared motor actuated through a reversing switch and governed by the primary relay.

Methods Used in Rating Motors

General Purpose Motors Rated in Three Ways. Type of Insulation Used Determines Maximum Temperature Which Is Permissible.

During the past few weeks the problem of arriving at a uniform basis for the rating of electric motors is one which has evoked considerable discussion among both manufacturers and users. The controversy was brought about by the introduction of the 50-deg., or continuous rating, as opposed to the 40-deg. rated machine, with its 25 per cent overload guarantee.

Manufacturers were not in accord as to the value of the 50 deg. rating and the users of motors were divided in their opinions as to the type of rating which would suit the requirements of their particular applications. In order to bring the two factions in line, the Electric Power Club at its annual meeting of June 13, 1923, finally agreed on a single rating which combined the features of both the 40 and 50 deg. ratings. This rating was not, however, adopted as a standard but was listed as recommended practice.

As a result, motors are in use today which are rated on any one of these three methods of rating. This lack of a standardized rating is likely to be somewhat confusing unless the principles of motor ratings are understood.

It may be stated that temperature is the deciding factor in the output of rotating electrical machinery. A motor may develop far beyond the horsepower for which it is designed, with a result that the temperature will rise to a point where the insulation will not stand up under the heat. It is true that the motor may slow down and ultimately stop, but during this time the horsepower output may be 200 per cent or more of rating.

Standard Ambient Temperature Is 40 Deg. C.

Quite naturally some starting point for measuring the increased temperature must be arbitrarily set. This temperature is called the ambient temperature and for rotating electrical machinery, where air is used or the cooling medium, this reference temperature is 40 deg. C. (104 deg. F.). A machine is therefore rated so that under the particular load conditions for which it is designed, the temperature of rise will not be above a certain figure.

A machine may be tested at any room temperature which is then the ambient temperature for the test. Regardless of what this ambient temperature may be, the permissible rise of temperature must not exceed that specified in the rating. The maximum ambient temperature is the ambient temperature of reference, or as previously stated, 40 deg. C.

Time and Torque Ratings

Obviously a motor which is to operate at peak loads for only a short interval of time can be rated higher than one which is subjected to steady load conditions. Between the peak loads the motor windings have a chance to cool off and so the insulation is not endangered by the short periods of high horsepower output.

It is for this reason that motors for elevator service hoisting duty, machine tool service, etc., are frequently rated on a time as well as temperature basis. The heating of machines operating under such conditions is equivalent to a continuous run for a specified time. The standard duration in minutes of load tests or time ratings for machines operating on such ratings are as follows: 5, 10, 15, 30, 60, 120 and continuous. Of these the first six are commonly known as short time ratings.

In addition motors for elevators and hoisting duty are rated on the basis of guaranteed starting torque and they are given a horsepower rating. The horsepower rating is the brake horsepower the motor will actually develop without exceeding the standard temperature rise for the standard time rating selected.

Since most of the motors used in power plant or general industrial work operate under continuous load conditions and do not require special design features, they fall under the classification of general purpose motors.

It is this large class of motors which have been rated on the 40 deg. or 50 deg. basis and more recently on the

single rating plan. A comparison will show the variation in these three methods of ratings:

Single rating.—An open type general purpose motor shall be capable of carrying full rated load continuously with a temperature rise not exceeding 40 deg. C. (104 deg. F.). As an additional note, it is stated that such a motor should be so designed as to be capable of carrying sustained overloads but in no event exceeding 50 per cent overload with an actual temperature of 90 deg. C. (194 deg. F.) measured by a thermometer.

40 deg.—A rating giving a 40-deg. C. (104 deg. F.) rise under continuous operation at rated capacity with a

TABLE I. STANDARD TEMPERATURE GUARANTEES FOR GENERAL PURPOSE MOTORS.

Class of Insulation	A
Load, Per Cent of Rated Capacity	100
Time Rating	Continuous
Temperature Rise	
1. core and windings	40 deg.
2. squirrel cage and amortisseur windings. *Any value which will not occasion mechanical injury to the machine or cause deterioration of surrounding insulation.	*
3. collector rings	
(a) If Class A insulation is employed in the collector rings, or is adjacent thereto and its life would be affected by the heat from the collector rings	65 deg.
(b) If Class B insulation is employed in the collector rings or is adjacent thereto	85 deg
4. commutators	
(a) If Class A insulation is employed in the commutator or is adjacent thereto and its life would be affected by the heat from the commutator	65 deg
(b) In all other cases	85 deg.
5. mechanical parts. **Temperature rise of all mechanical parts not in contact with insulation may be such as will not be injurious in any respect.	**

2 hr., 25 per cent overload guarantee with a temperature rise not to exceed 55 deg. C.

50 deg.—A rating giving a 50-deg. C. (122 deg. F.) temperature rise under continuous operation at rated capacity without overload guarantee.

One of the chief objections to the 50-deg. rating is the fact that no provision is made for meeting unusual load conditions, hence many engineers have felt that the factor of safety is too low. On the other hand, the advocates of this type of rating have claimed that over-motoring is the main cause of low power factor and that the application of 50-deg. motors would tend to correct this condition.

It will be noted in comparing the new rating with the former 40-deg. rating, that overload capacity is not definitely guaranteed. The burden of responsibility for the failure of a motor due to overload conditions is placed on the user. The manufacturer simply states that the motor will operate at its rated horsepower with a temperature rise not exceeding 40 deg. C. although advantage may be taken of favorable operating conditions to operate the motor on overloads as high as 50 per cent, provided the final temperature is not above 90 deg. C. This rating therefore gives both the designer and the user more latitude.

It should be understood that this new rating applies only to general purpose motors. Other temperatures are used such as 50, 55, 70 and 75 deg. C., for special applications, where the load and duty cycle are of a type such as found in elevator or hoisting service.

For the high temperatures it is necessary to use a different type of insulation from that used for general purpose motors. There are two main classifications of insulation in use known as Class A and Class B. Class A insulation consists of cotton, silk, paper and similar materials which are treated or impregnated, to increase the thermal limit, or which are permanently immersed in oil. Also enameled wire and silk or cotton covered enameled wire. Class B insulation includes such materials as mica and asbestos, which are capable of resisting high temperatures. Class A material may be used with Class B materials for structural purposes, but the destruction of the class A material must not affect the insulating or mechanical properties of the insulation.

As an illustration of the use of these two types of insulation, Tables I and II are presented. Table I shows the 40-deg. rating of general purpose motors, with Class A insulation while Table II shows the higher temperature which may be used with class B insulation. Both of these tables are for polyphase motors but the temperature ratings

TABLE II. TEMPERATURE GUARANTEES USED WHERE MOTORS ARE RATED ON BASIS OF 50, 55, 70 AND 75 DEG. C.

Class of Insulation	A	B
Load, Per Cent of Rated Capacity	100	100
Time Rating	*	*
*Time rating may be continuous or any standard short time continuous time rating. See Rule 5300.		
**Not including open type general purpose motors with rating. See Rule 6530.	**	**
Temperature Rise		
1. core and windings		
(a) Fully enclosed motors	55 deg.	75 deg.
(b) All other types	50 deg.	70 deg.
2. squirrel cage and amortisseur windings. †Any value which will not occasion mechanical injury to the machine or cause deterioration of surrounding insulation.	†	†
3. collector rings		
(a) If Class A insulation is employed in the collector rings, or is adjacent thereto and its life would be affected by the heat from the collector rings	65 deg.	65 deg.
(b) If Class B insulation is employed in the collector rings, or is adjacent thereto	85 deg.	85 deg.
4. commutators		
(a) If Class A insulation is employed in the commutator, or is adjacent thereto and its life would be affected by the heat from the commutator	65 deg.	65 deg.
(b) In all other cases	85 deg.	85 deg.
5. mechanical parts. ††Temperature rise of all mechanical parts not in contact with insulation may be such as will not be injurious in any respect.	††	††

and the restrictions on the insulation are the same for direct current motors and generators.

It is also well to keep in mind that enclosing or semi-enclosing covers reduce the rating of a motor. In the case of the fully enclosed motor the rating is reduced about one-half. A 10-hp. general purpose motor, if enclosed, would ordinarily be rated at 5 hp. with a temperature rise of 55 deg. C. Semi-enclosed motors with perforated covers will develop normal open rating continuously with temperature rise not to exceed 50 deg. C.

For semi-enclosed motors where gauze is used in the covers, normal open horsepower rating may usually be used on a 1-hr., 50-deg. C. rise basis or 75 per cent of the normal open horsepower rating for continuous operation at 50 deg. C. rise. These temperatures refer to motors where class A insulation is used and form a rough way to estimate the size of the enclosed motor from open type general purpose motor lists.

Test of a Prosser Type Steam Engine

Correction: On page 187, February 1 issue, are shown two tables, the captions of which are interchanged. The caption for Table I, at the top of the page, should read "Average Observed and Computed Results, Superheated Steam," and the caption for Table II, shown at the bottom of the page, should read "Average Observed and Computed Results, Saturated Steam."

New Addition to Joliet Plant Completed

New Boilers and Turbine Unit Installed in Joliet Plant of Public Service Co. of Northern Illinois

APPROXIMATELY seven years ago, the Public Service Co. of Northern Illinois placed in operation at Joliet, Ill., a new generating station—Station No. 9. At that time this station attracted considerable attention among power plant men because of the high boiler pressure used. Pressures of five hundred and twelve hundred pounds were unknown in those days insofar as practical considerably. This increased demand for power resulted in the construction of an addition to the station during the past year and the installation of a new 30,000-kw. generating unit together with all auxiliaries and boilers. The details of this new installation are described in this article.

As described in the March 1, 1918, number of Power Plant Engineering, Station No. 9 is located about 4 mi.

FIGS. 1-4. GENERAL VIEWS AT JOLIET PLANT

Fig. 1. Distributing Belt Conveyor Above Coal Bunkers. Fig. 2. One of the New Centrifugal Boiler Feed Pumps. Fig. 3. Coal Is Unloaded from Railroad Cars by Means of This Gantry Crane. Fig. 4. Exterior View of Station No. 9 Showing Coal Handling Equipment.

applications were concerned and the installation of boilers for 350 lb. working pressure in the Joliet station was a notable achievement and was regarded with great interest.

The original installation consisted of two 10,000-kw. General Electric Co. turbo-generators and four Babcock & Wilcox cross-drum boilers having a heating surface of 9919 sq. ft. each. Unit No. 1 together with three boilers was placed in operation in 1917 while Unit No. 2 and the fourth boiler went into service in 1918. This equipment has been in practically continuous operation since its installation.

While Station No. 9 is one of a number of generating stations supplying the transmission and distribution system of the Public Service Co. of Northern Illinois, it is located in a growing industrial area and, during recent years, the demands for power in this area have increased southwest of Joliet on the Chicago & Alton Railway and the Atchison, Topeka & Santa Fe Railway and adjacent to the Desplaines River. The location is therefore advantageous for supplying coal and condensing water.

Handling the Coal

In the initial installation coal was unloaded by a traveling bridge crane into a crusher which discharged into a Link-Belt bucket elevator and conveyor which in turn delivered it to the overhead coal bunkers in the boiler room. This system has now been supplemented by the new conveyor system shown in the photographs Figs. 1 and 3. With this system, coal is unloaded from cars into a hopper by a gantry crane, and by means of a shaking feeder and belt is delivered to a Bradford breaker where it is reduced to the proper size for use on the stokers. From

the breaker it is carried by conveying belts to the top of the boiler house and is distributed in the coal bunkers through the agency of an automatic tripper. The new coal-distributing belt travels the entire length of the boiler house, the old part as well as the new. It thus takes the place of the old conveyor system which, however, is still in operating condition and is available for emergency use in the original installation at any time the new system should develop trouble.

and lower tube decks. It has a heating surface of 2286 sq. ft. which gives a ratio of superheating surface to boiler heating surface of 1 to 6.17. These units will superheat 150,000 lb. of steam per hr., 281 deg. F.

These boilers are equipped with B. & W. blast type chain grate stokers rated to burn 62.1 lb. of coal per sq. ft. of grate surface per hr. when evaporating 150,000 lb. of water per hr. or at 337 per cent rating. Under these conditions they burn 23,800 lb. of coal per hr. The grates

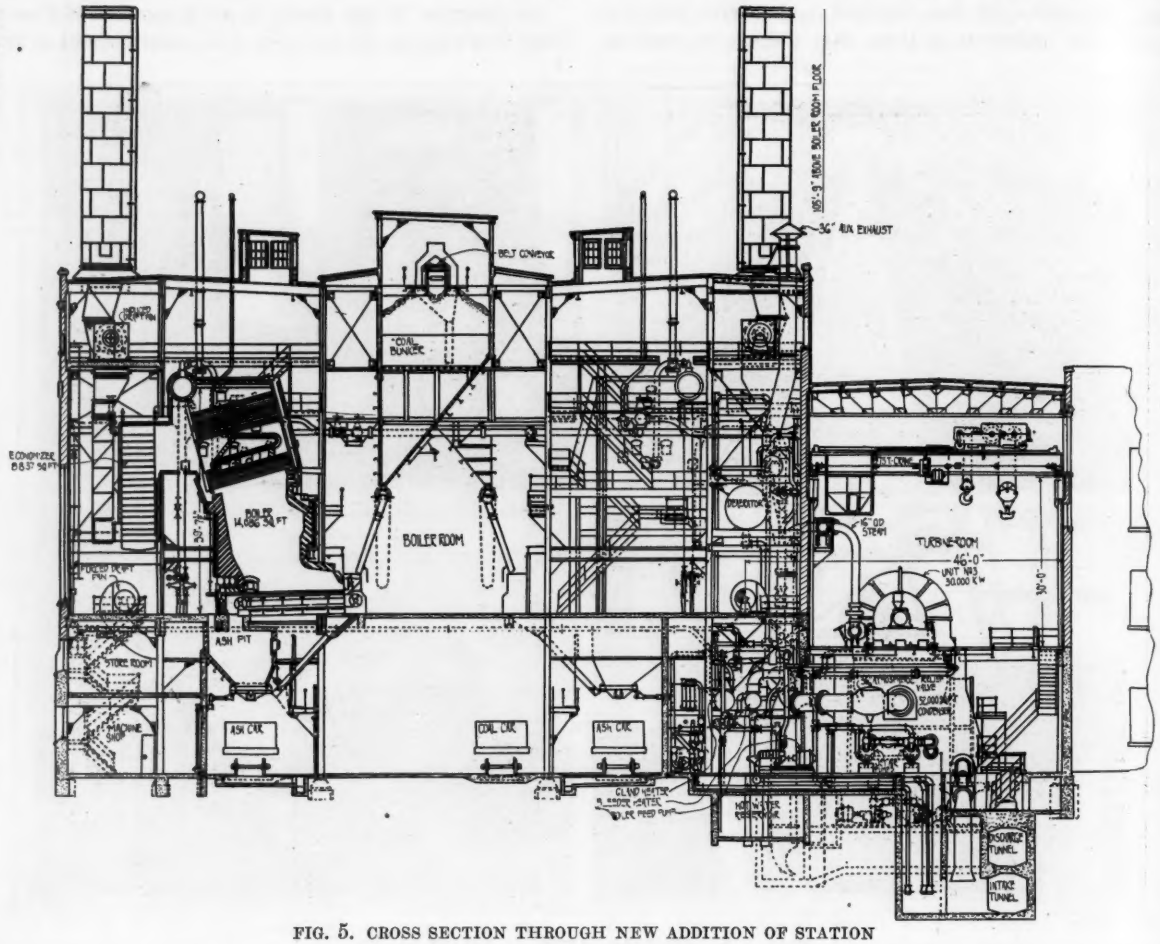


FIG. 5. CROSS SECTION THROUGH NEW ADDITION OF STATION

The capacity of the present coal handling system is 180 T. per hr. The overhead bunkers are of steel with gunite lining and have a capacity of 1000 T. In the yard, outside the building, there is additional storage capacity for 75,000 T. of coal which is reclaimed for use by means of locomotive cranes. Coal is weighed on track scales and by means of a weightometer on the belt.

New Boiler Equipment

Four new boilers have been installed. These are Babcock & Wilcox units of the double deck type each rated at 1409 hp. and provided with 14,086 sq. ft. of heating surface. There are two passes in the upper deck and a single pass in the lower deck. The lower deck is 8 tubes high, 34 wide and the tubes are 3¼ in. in diameter and 15 ft. long. The upper deck is 17 tubes high, 68 tubes wide, the tubes in this deck being 2 in. in diameter and 15 ft. long. The superheater which is of B. & W. manufacture is integral with the boiler and is located between the upper

measure 18 ft. 3 in. by 21 ft. which gives a projected grate area of 383 sq. ft. The amount of gas handled at 337 per cent rating is 241,000 lb. per hr., while at 170 per cent, it is 114,000 lb. per hr.

The stokers are each driven by a 10-hp. 440-v. General Electric variable speed alternating-current motor through a gear and belt drive. Speed control of the stokers is effected through the use of an electric controller and gear box. The controller provides ten different speeds on the motors for each position on the gear box and since the latter is arranged for four changes in speed, a total of 40-speed changes is obtained.

An interesting fact regarding this stoker installation is that it marks the first successful application of a.c. drive to chain grate stokers. Alternating-current motors had been used before on the underfeed type of stoker but not on chain grates.

The furnaces are fitted with Detrick flat arches and regular fire brick linings. The furnace volume is 5560

cu. ft. per boiler which gives a ratio of furnace volume to water heating surface of 1 to 2.53. The ratio of furnace volume to projected grate area is 14.5 to 1.

For heating the feed water to a high temperature and to reclaim heat in the stack gases, each boiler is fitted with a "Duratex" type steel tube economizer, made by the B. & W. Co. These economizers are installed at the rear of the boilers, have 840 tubes, 20 ft. long, 8837 sq. ft. of heating surface and when handling 150,000 lb. of water

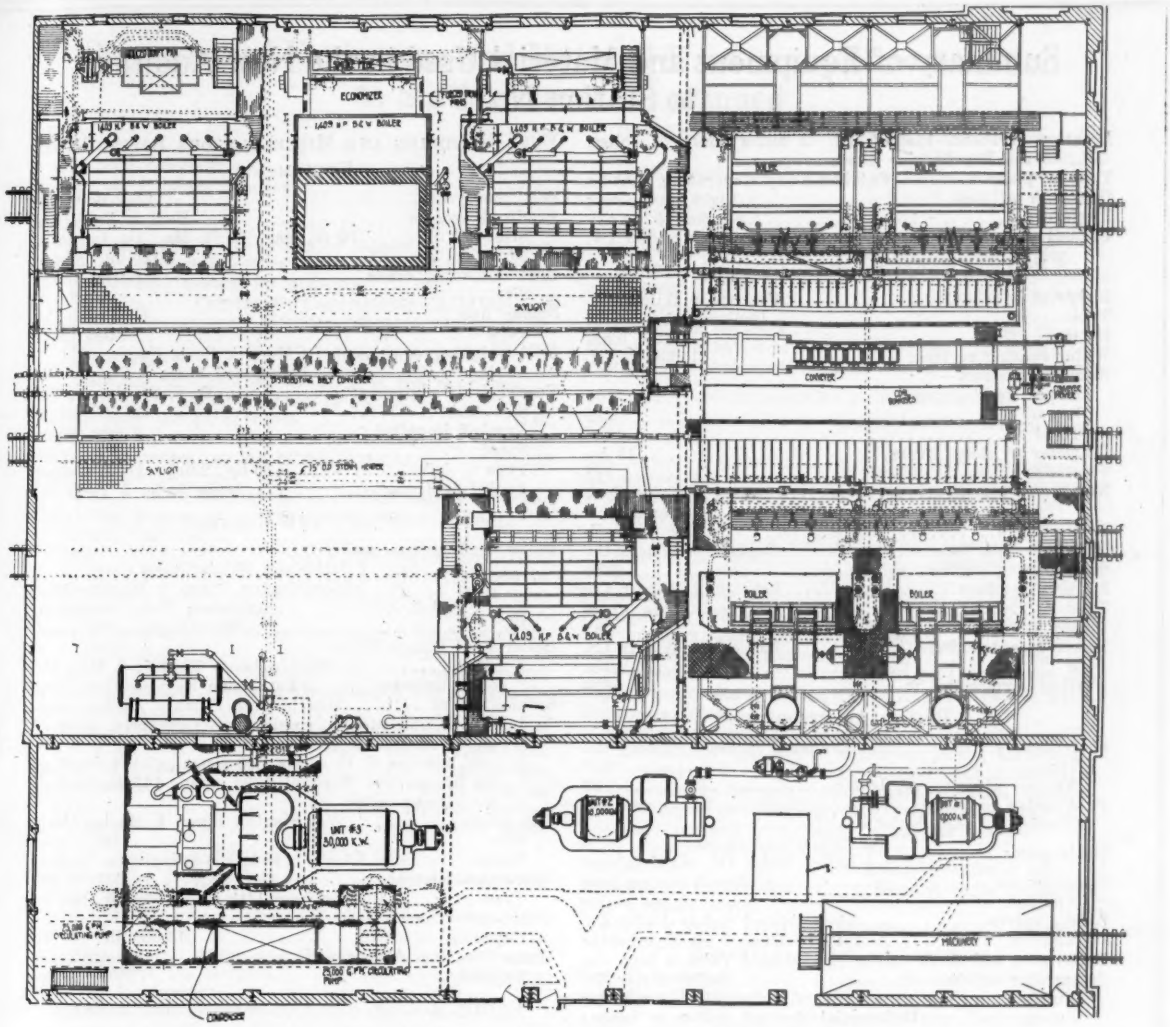


FIG. 6. PLAN VIEW OF PRESENT STATION SHOWING NEW ADDITION AT LEFT

per hr. will raise the temperature from 150 to 280 deg. F. The pressure maintained in the economizers is approximately 400 lb. per sq. in. The flue gases enter the economizer at a temperature of approximately 590 deg. F. and leave at approximately 350 deg., a temperature difference of about 240 deg. F.

Boiler operation is effected through the use of both forced and induced draft. Eight special design Turbo Vane forced draft fans are installed, two for each boiler. These are rated to handle 35,000 cu. ft. of air per min. at 65 deg. F. against 3 in. of water when running at 860 r.p.m. They are driven by 2300-v. variable speed 30-hp. motors remote controlled from the firing aisle.

The average run of coal used has a heat value of 11,100 B.t.u. per lb. as received and contains the following percentages of elements: ash, 10.87 per cent; carbon, 63.19 per cent; hydrogen, 3.94 per cent; sulphur, 1.88 per cent; nitrogen, 1.40 per cent; oxygen, 9.05 per cent.

Steam pressure carried at the boilers is 350 lb. with a total temperature of 700 deg. F. Feed water leaving the heater and entering the economizer has a temperature of 150 deg.

Ash is delivered from the ashpits below the boilers into cars in the basement through Allen-Sherman-Hoff ash gates. These ash gates are operated by compressed air at 100 lb. per sq. in.

The new generating unit is a 30,000-kw. 1800 r.p.m. machine made by the General Electric Co. It has 17 stages and operates on a steam pressure of 300 lb. and at total temperature of 700 deg. F. The weight of the unit is 22 lb. per kw.

The electrical end of the turbo-generator unit consists of a 35,300-kv.a., 12,000-v., 3-phase, 60-cycle generator with direct connected exciter. This machine is fitted with a Carrier air conditioning system, which is capable of treating 80,000 cu. ft. of air per min. for ventilation. The exciter capacity is 0.47 per cent of the generator capacity.

Vacuum is maintained at 29 in. Hg. by a Wheeler Condenser & Engineering Co. surface condenser with a capac-

ity of 330,000 lb. per hr. It has 11,200 one-inch tubes 18 ft. 3⅜ in. long made of seamless drawn brass, giving a total cooling surface of 52,000 sq. ft. This condenser is supported on springs and connected solidly to the turbine exhaust nozzle.

Air removal is effected by means of two 2-stage steam ejector type vacuum pumps rated at 20 cu. ft. per min. at 29 in. Hg. Condensate is handled by two double-stage centrifugal pumps driven by 100-hp., 1200 r.p.m. electric motors.

Because of the character of the circulating water, which contains considerable suspended matter, it is necessary to watch the condition of the condenser tubes carefully. When they become dirty, they are cleaned by means of rubber plugs forced through with air pressure or by using wire brushes and water.

Two 30-in. double-suction type, 300-r.p.m. centrifugal circulating pumps capable of supplying 35,000 g.p.m. at 15 ft. head are provided. These are each driven by 300-hp. electric motors. The above ratings are for the pumps operating singly. When the two pumps are operating in parallel the head is increased and the total amount of water supplied is 50,000 g.p.m. or a capacity of 1.67 g.p.m. per installed kilowatt.

General Features of New Addition

In building the new addition, the same architectural features were followed that characterized the old part and so far as internal and external appearance is concerned, the new part and the old part form one continuous building. Four new unlined steel stacks have been added. These are 8 ft. 6 in. in diameter with the top 103 ft. above the grate and are supported on the building steel. The stack area per 1000 sq. ft. of boiler heating surface is 4.03 sq. ft.

The buildings are constructed of steel, concrete and brick, the foundations being concrete footings on solid rock. The site of the building is an old stone quarry floor.

The interior of the boiler is finished with common brick painted, but the turbine room is white enamel brick. The turbine room floor is red Gruby hexagon tile. Windows are plain glazing set in steel sash.

Summary of Equipment and Material Used in the New Addition to Station No. 9

Location of Plant, Plaines, Ill. 3 Miles South of Joliet, Ill., on the Des Plaines River.
Type of plant.....Public Utility Generating Station
Character of load.....Light and power
Engineers.....Sargent & Lundy
Present capacity of plant.....50,000 kw.

Boilers, Superheaters and Furnaces

Maker of boilers.....Babcock & Wilcox Co.
Type.....Inclined, water tube
Rating.....1409 b.hp.
Water heating surface.....14,086 sq. ft.
Number of Tubes—
  Upper deck.....1156
  Lower deck.....272
  Total.....1428
Diameter of steam drum.....48 in.
Thickness of shell, inches.....1 11/32
Number of passes.....2 passes in upper deck
  1 pass in lower deck
Type of arch.....Detrick flat arch
Maker of superheaters.....Babcock & Wilcox Co.
Superheating surface, sq. ft.....2286
Maker of stokers.....Babcock & Wilcox Co.
Type.....Blast chain grate
Projected grate area, sq. ft.....383
Maker of economizers.....Babcock & Wilcox Co.
Type.....Duratex
Heating surface, sq. ft.....8837

Boiler Accessories

Soot blowers.....Diamond Power Specialty Co.
Type.....G-9
Number of units, per boiler.....22
Feed water regulators.....Northern Equipment Co.
Number on each boiler.....1
Draft gages.....{Ellison multi-tube / Bailey Meter Co. multi-pointer}
Steam gages.....Ashcroft spring type
Number.....2 per boiler
Safety valves.....Consolidated Safety Valve Co.
Number.....4 per drum, 1 on superheater
Boiler stop and check valves.....Edward Valve & Mfg. Co.
Steam flow meters.....Bailey Meter Co.
Number.....1 per boiler
Type.....Differential through orifice in header
Thermometers.....C. J. Tagliabue Mfg. Co.
Type.....Indicating

Fuel Handling and Miscellaneous Boiler-Room Equipment

Belt conveyors.....Link-Belt Co.
Bradford breaker.....Heyl & Patterson
Size.....16 ft. long, 12 ft. dia., 1¼ in. holes
Drive.....100-hp. motor
Coal unloading crane.....Whiting Corp.
Size.....2 yd.
Smoke flue.....H. Pratt Co.
Type.....Steel plate
Coal weighing equipment.....{Merrick Scale Co. / Standard Scale & Supply Co.}
Forced draft equipment.....B. F. Sturtevant Co.
Size fans.....35,000 c.f.m.
Number installed.....2 per boiler
Speed.....860 r.p.m.
Type of drive.....30-hp., 2300-v. G. E. motors
Forced draft ducts.....Acme Boiler & Tank Co.

Pumps and Heaters

Boiler feed pumps, maker.....{Bethlehem Shipbuilding Corp. / Worthington Pump & Machy. Corp.}
Nos. 1 and 2.....Bethlehem Weir, 700 g.p.m.
No. 3.....Worthington, 700 g.p.m
Boiler Feed Pumps Drive—
1 motor.....Westinghouse Electric & Mfg. Co.
2 steam turbines.....Bethlehem Shipbuilding Corp.
Service pumps.....Worthington Pump & Machy. Corp.
1, 4-in., double-suction, single-stage, slow-speed, 1000 g.p.m. at 1800 r.p.m.
1, 5-in., 2-stage, S. D. series, 750 g.p.m., 470 ft. head for fire service. Parallel, 1000 g.p.m., 145 ft. head for service water.
Fire pump.....Worthington Pump & Machy. Corp.
Size.....750 g.p.m.
Drive.....140-hp. Westinghouse turbine
Extraction heater.....Elliott Co.
Type.....Bleeder from 14th stage, 9000 lb. per hr.
Gland and exhaust steam heater.....Elliott Co.
Capacity.....15,000 lb. per hr.
Water treating system.....Permutit Co.
Capacity.....7500 g.p. hr.

Prime Movers and Condensing Equipment

Turbo-generator.....General Electric Co.
Rating.....35,300 kv.a.

Feed water make-up is drawn from the river through an intake well and is treated by means of a Permutit water treating system with a capacity of 7500 gal. per hr. The amount of make-up water treated daily is approximately 3 per cent of the total amount fed to the boilers. Feed water is delivered to the boilers by three 700-g.p.m. centrifugal pumps, Nos. 1 and 2 of which are turbine driven at 4600 r.p.m., and No. 3 is motor driven. Feed water is heated by extraction steam and gland steam from the main unit and exhaust steam from the steam-driven auxiliaries. Water level in the boilers is controlled by Copes regulators one on each boiler.

Condensate is taken from the condenser by the condensate pumps and pumped through the main condenser of the deaerating system, then through the bleeder heater where its temperature is raised to approximately 165 deg. F. and then through the gland heater where the temperature is further raised to 179 deg. F. Make-up water is drawn from what is known as the hot water reservoir into the hotwell. The hotwater reservoir receives the discharge from the traps, all drips and drains from steam headers, and the overflow from the deaerator. Constant level is maintained in the hotwater reservoir by float valves which admit water treated by the Permutit Zeolite system.

After leaving the gland heater, the water enters the deaerator and from there is delivered to the economizers by the boiler feed pumps, after which it enters the boilers.

Constant level is maintained in the deaerator by means of float valves which control admission of the condensate. In case of an excess of condensate, the excess is rejected to the hotwater reservoir, while in case of a deficiency of condensate, such deficiency is made up by treated water admitted through a float valve. In the event that the treated water supply fails or is insufficient, raw water is admitted to the deaerator through float valves.

The bleeder heater is fed by steam bled from the fourteenth stage of the turbine. The gland heater receives the gland steam from the turbine and also the steam from the steam-driven auxiliaries after desuperheating. Part of the condensate is used in the inter and after coolers of the air evactors and part is used in desuperheating the steam entering the gland heater. In winter the average tempera-

Summary of Equipment and Material Used in the New Addition to Station No. 9—Continued

Speed ..... 1800 r.p.m.
Steam pressure at throttle ..... 300 lb.
Total steam temperature ..... 700 lb.
Weight per kilowatt capacity ..... 22 lb.
Voltage 12,000
Exciter voltage 250
Ratio exciter capacity to generator capacity 0.47%
System of exciter lubrication ..... Oil ring lubrication
Air conditioning system for generator ..... Carrier Air Conditioning Co. of America
Condenser ..... Wheeler Condenser & Engrg. Co.
Type ..... Surface
Performance ..... 330,000 lb. steam per hr. at 1 in. Hg. back pressure and cooling water at 70 deg. F.
Cooling water per lb. of steam ..... 73 lb.
Number of tubes 11,200
Sq. ft. tube surface per kw. of prime mover 1.733
Type of tube packing ..... Fiber at one end corset lace at other end
Circulating pumps ..... Wheeler Condenser & Engrg. Co.
Number installed 2
Type ..... Double-suction centrifugal
Size ..... 30 in.
Capacity ..... 35,000 g.p.m. at 15 ft. head
Drive ..... 300-hp. motors
Vacuum pump ..... Wheeler Condenser & Engineering Co.
Number installed 2
Type ..... 2-stage evactor
Condensate pumps ... Wheeler Condenser & Engineering Co.
Number 2
Type ..... Double-stage centrifugal
Drive ..... 100-hp. motor, 1200 r.p.m.
Ejector for priming condenser ..... 4-in. Westinghouse
Water screens ..... Chain Belt Co.
Type ..... Rex Inclined, pivoted
Drive ..... 5-hp. 440-v. motor

Electrical Equipment

Station service transformers ..... Allis-Chalmers Co.
Type and size ..... 2000-kv.a., 3-phase, 12,000/2300-v. water-cooled
Protective reactors ..... General Electric Co.
On station aux. trans. and feeders .. 111 kv.a., 400 amp.
On 12,000-v. bus sections ..... 1860 kv.a., 2550 amp.
Switching Equipment—
145,000-v., 400-amp., 3-pole, single-throw motor operated air-break switch on 132-kv. line ..... Hi-Voltage Equipment Co.
15,000 v., 2000 amp. on generator and transformer .. General Electric Co.
15,000 v., 400 and 800 amp. for 2300-v. auxiliaries .. Condit Electric Mfg. Co.
Switchboard—
Type ..... Gallery
Manufacturer ..... Westinghouse Electric & Mfg. Co.
Number of panels .. 2-panel bench and 2 vertical panels
Material and finish ..... Natural black slate
Supports ..... Pipe
Disconnecting switches ..... Delta Star Co.
Bus and cable supports ..... Delta Star Electric Co.
Voltage of transmission system ..... 33,000 v.

Miscellaneous Equipment

Station crane ..... Whiting Corp.
Capacity ..... 75 T.
Ash gates ..... Allen-Sherman-Hoff
Oil purification system ..... DeLaval separator
Pipe covering ..... Johns-Manville, Inc.
Steam lines ..... Asbestos-sponge felt, double standard magnesia
Exhaust lines, etc. ..... Standard magnesia
Water lines ..... Anti-sweat
Piping contractor ..... Wm. A. Pape
High pressure steam gate valves ..... Crane Co.
Low pressure steam and water fittings ..... Crane Co.
Low pressure steam and water piping ..... Crane Co.
Material ..... Cast-iron and wrought steel
High pressure steam joints, type ..... Sargol welded
Expansion Joints—
All piping connections to condenser except at hotwell made through rubber expansion joints, manufactured by U. S. Rubber Co. Connections at hotwell are made through copper expansion joints, manufactured by Crane Co. Condenser is supported on springs and bolted solid to turbine exhaust.
High pressure globe and angle valves ..... Edward Valve & Mfg. Co.
Atmospheric relief valve ..... Edward Valve & Mfg. Co.
Drip systems, traps ..... Crane Co.
Circulating water pipes and fittings ..... Crane Co.

Miscellaneous Instruments

Venturi meters ..... Builders Iron Foundry
Recording thermometers and vacuum gages ..... Brown Instrument Co.
Turbine signals and load bulletins ..... Westinghouse Electric & Mfg. Co.

ture of the raw make-up water is 35 deg. F. while in summer it is 70 to 80 deg. F.

Circulating water for the condensers is obtained from the Desplaines River. All circulating water passes through inclined pivoted water screens installed in a crib house on the river side of the plant. These are driven by 5-hp. 440-v. a.c. induction motors running at 900 r.p.m. The screens travel at the rate of 10 ft. per min. and are cleaned continuously by means of a spray.

The plant was designed by Sargent & Lundy of Chicago, the architectural features being handled by H. V. Von Holst, architect. In concluding this description we wish to extend thanks to the officials of the Public Service Co. of Northern Illinois for supplying us with the data used in the preparation of this article.

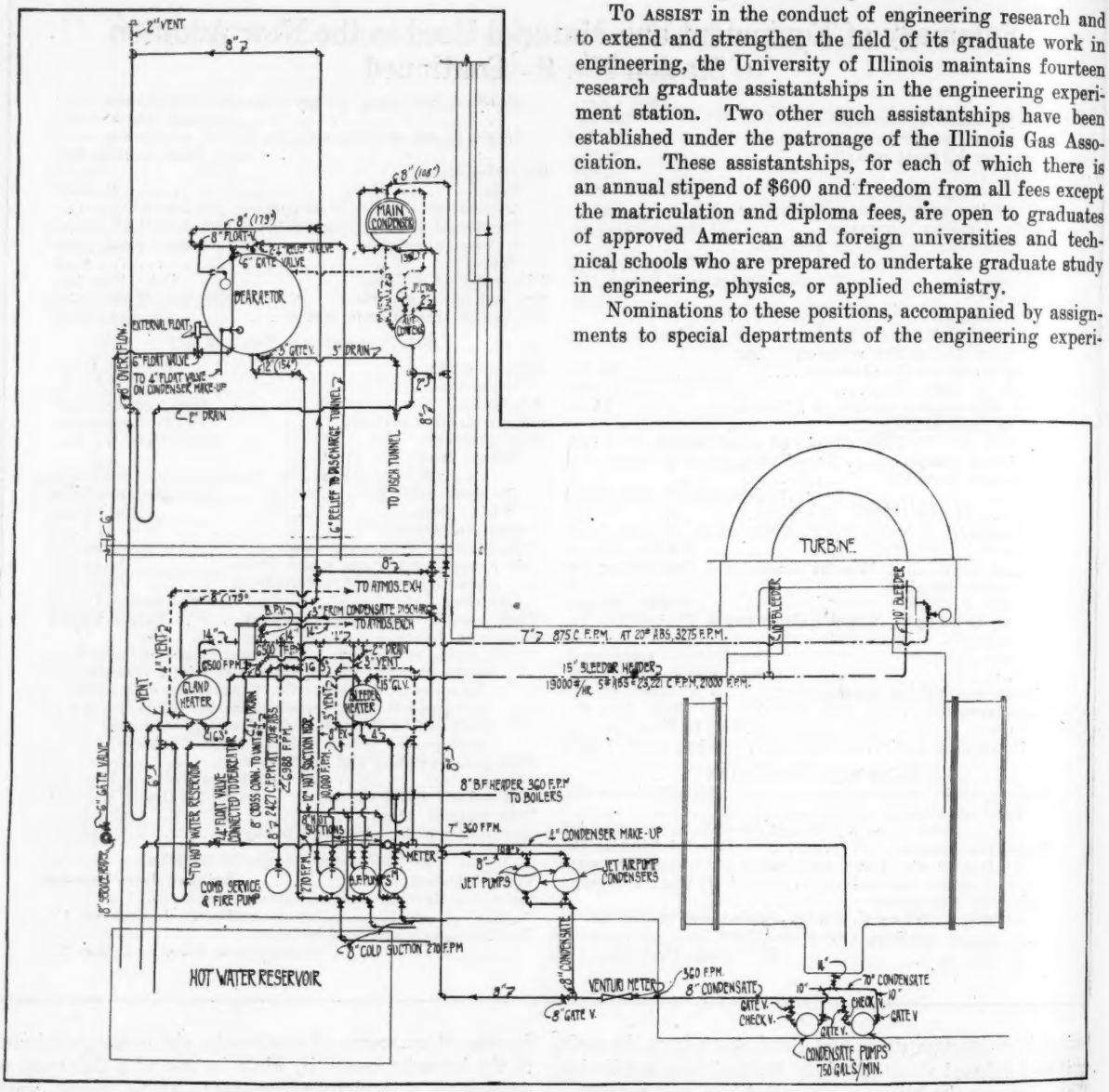


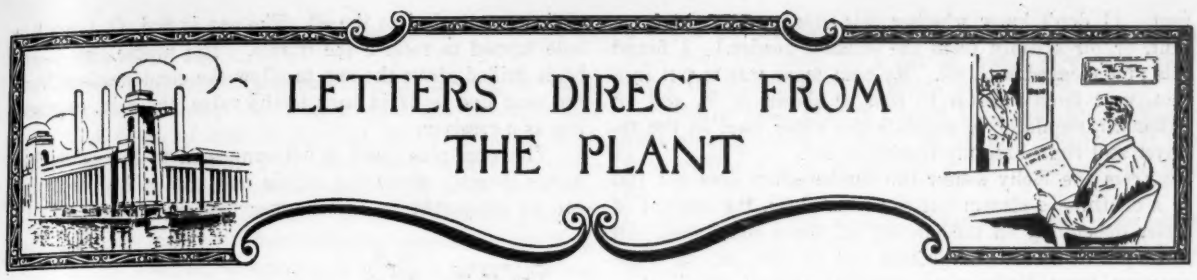
FIG. 7. HEAT BALANCE DIAGRAM OF NEW UNIT

Construction on this addition to Station No. 9 was started Jan. 2, 1923. The 30,000-kw. turbine was placed in operation of Jan. 23, 1924. At this time the installation of the new boilers was not yet completed so the new turbine was supplied with steam from the boilers in the original installation. The first of the new boilers was put on the line on Feb. 27, 1924, and the last one on June 2, 1924.

Graduate Assistantships to Be Appointed by U. of I.

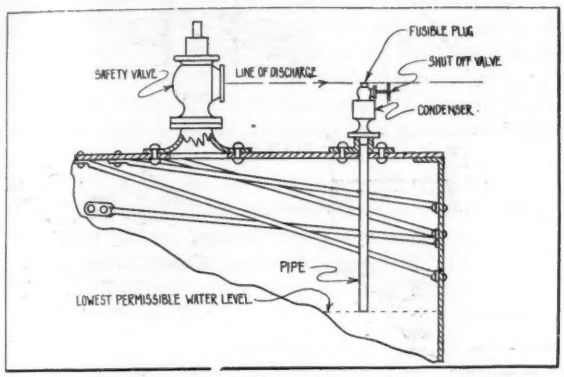
To ASSIST in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen research graduate assistantships in the engineering experiment station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

Nominations to these positions, accompanied by assignments to special departments of the engineering experiment station, are made from applications received by the director of the station each year not later than the first day of April. Nominations are based upon the character, scholastic attainments, and promise of success in the principal line of study or research to which the candidate proposes to devote himself. Additional information may be obtained by addressing the Director, Engineering Experiment Station, University of Illinois, Urbana, Ill.



Safety Valve Discharge Too Near Fusible Plug

TROUBLE WAS experienced with the external type fusible plug of one of a battery of two H. R. T. boilers in our plant. The fusible plug of No. 2 boiler persisted in blowing once or twice a week, apparently without cause.



SKETCH SHOWING HOW VALVE DISCHARGED DIRECTLY ON EXTERNAL FUSIBLE PLUG

Various plugs and remedies were tried without locating the trouble. During all this time the fusible plug on No. 1 boiler gave no trouble.

In looking over the boilers, I noticed that No. 1 boiler carried two safety valves of the lever type, set on a tee base, while No. 2 boiler carried one valve of the spring type connected to the boiler as shown on the sketch. Further investigation showed that all our trouble was due to the location of No. 2 single safety valve. The discharge opening of this valve was located on a line with the fusible plug, as shown. Each time the valve popped, steam impinged directly on the fusible plug, softening the fusible metal, causing some of it to be forced out by the pressure within the boiler and leaving in the plug a thin section which would give way a little later. The trouble was remedied by turning the discharge opening of the safety valve 45 deg.

No. 1 boiler gave no trouble due to the fact that the two safety valves, which were located on a tee base, were not in line with the fusible plugs.

Chicago, Ill. MARTIN GRYCH.

Poor Receiver Piping Causes Water Hammer

UPON taking charge of a small mill plant consisting of one 125-hp. Rollins engine, running the mill and a 100-kw. generator and one H. R. T. boiler, I was welcomed with the pleasant news that they had broken the steam valves on the engine three times in two weeks and that they had had four different engineers in that time. Nobody seemed to know exactly what caused the trouble, but, as often happens, everybody came to the conclusion that the engineer carried water too high in the boiler.

Everything went well the first morning until about 11 o'clock in the forenoon, when, in going from the boiler room to the yard, I got a shower of water over me. Looking up to the roof, I saw water blown up four or six ft.

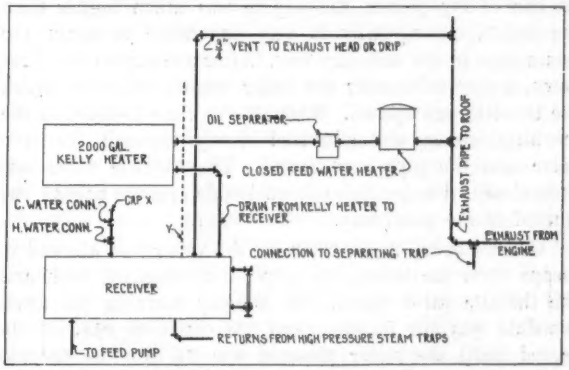


DIAGRAM OF CONNECTIONS, SHOWING HOW RECEIVER WAS VENTED TO CORRECT TROUBLE

from the exhaust header and when I went back to the engine room, I could tell by the way the engine was laboring and pounding that something was wrong.

As I was sure that the boiler did not foam or prime and as I was carrying only 2 in. of water in the glass, I refused to believe that water was coming over with the steam. However, I made up my mind not to shut the engine down as long as I saw water coming out, even if I had to stay until midnight and take the steam off the boiler. I did not have to do the latter, because just before shutting down time at night everything was all right.

That night, I stayed over and tried out the heaters and traps and traced out all the piping, but apparently everything was all right. The next day, in blowing down the gage glass on the receiver, I found pressure in the receiver at certain times, so I unscrewed the cap X on the end of a 1½-in. pipe, placed on top of receiver for hot and cold make-up water. In taking this cap off, the force from inside forced it out of my hand and a stream of water was sent up 8 ft. to the bottom of the Kelly heater hanging above, compelling me to put an empty bag over the pipe to protect the asbestos covering on the heater. This water made a mess on that side of the boiler room, but I considered myself well paid for this inconvenience, when I saw no more water on the roof and the engine started to run easily and quietly.

Knowing that I had pressure in the receiver I disconnected the ¾-in. pipe that I supposed was meant for a

vent. (I don't know whether this pipe was put in for a vent, or for a drain from the exhaust header.) I found this pipe clogged with oil. My next move was to put in a 2-in. vent from receiver to roof as shown at Y, and an automatic regulator to regulate the water level in the receiver and right here my trouble ended.

From the Kelly heater the condensation does not run in a continuous stream but comes in slugs, the amount of water depending on the amount of steam condensed. Of course, with no water regulator and no vent, having high-pressure traps discharging into the receiver, the condensation from the heater went back through the exhaust pipe and out onto the roof as long as the engine was running. The trap on the lower end of exhaust pipe took care of some of the water.

Boston, Mass. CHARLES MAGNUS.

Condensation in Steam Lines

WATER SOMETIMES does damage in the steam pipe of an engine before it has a chance to get into the cylinder. In one of my plants, the engine was much higher than the boiler, consequently it was impossible to drain the steam pipe in the ordinary way. After the engine was shut down, a stop valve near the boiler was closed, after which the throttle was opened. When it was time to start in the morning, steam was admitted slowly through the stop valve and the pipe was heated. The throttle valve was then closed, the stop valve opened wide and the engine was started in the usual way.

One Saturday night when all the water was allowed to escape from the boiler, the stop valve remained open and the throttle valve closed. On Monday morning the usual schedule was not followed and the omission was not observed until the boiler pressure was 11 lb. The throttle valve was then raised from its seat very cautiously but a loud report quickly followed and the valve was ruptured. The mill was not run that day and a valuable lesson was learned.

On one occasion, we were at a loss to account for the lowering of the water level in our boiler when the plant was shut down overnight. Upon careful investigation, it was found that the trouble was caused by a newly installed throttle valve at the main engine. This valve was one of the type that uses a hard-rubber disc, which I had believed would be satisfactory under these conditions. We found, however, that when the valve was closed at night, water condensed in the valve and in the line above it, and the reduction of temperature caused the valve disc to contract. The condensed water passed through the valve and was followed by a quantity of steam, which raised the temperature, expanded the disc and closed the line until the steam condensed again. As this cycle was repeated frequently during the night, it was no wonder that considerable steam was used and the water level in the boiler lowered.

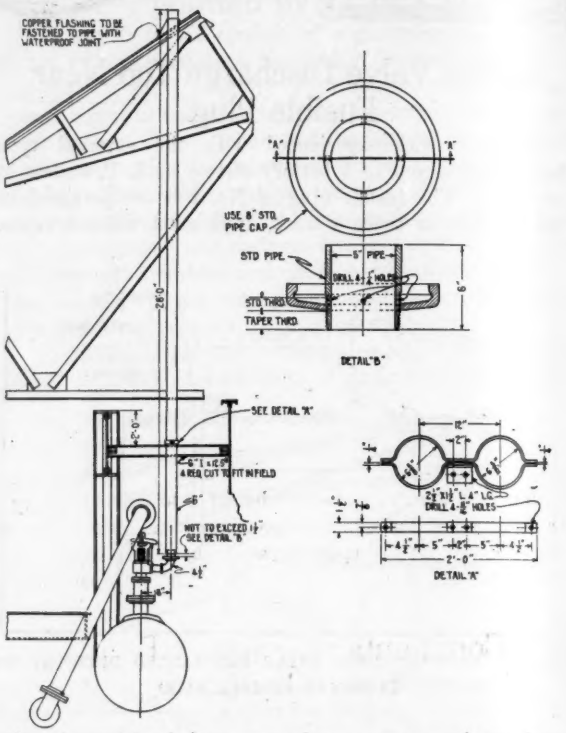
New Haven, Conn. W. H. WAKEMAN.

Supporting Safety Valve Vent Pipes

DURING the writer's experience in a pipe fabricating company, the following method of supporting safety valve vent piping was noticed.

Safety valves to be provided with vents were 4½ in., as shown on the sketch. Each valve was provided with a short nipple on the outlet and to this nipple attached an ell. A short nipple with an 8-in. cap, as shown in detail "B", was attached to the ell. The cap is Std. C. I. with a hole tapped to receive the nipple. The nipple has ¼-in. holes drilled above the cap to allow the condensation from the vent line to drain back to the valve, the 8-in. cap acting as a receiver.

The vent pipe itself is not connected to the valve, but hangs directly above the nipple and cap. The vent pipe can be supported in any manner that is convenient. In this case it is hung on a 6-in. I-beam, which in turn is fastened to the building framework. Detail "A" shows the type of clamp used to hold the vent pipes in place.



SKETCH SHOWS SUPPORT FOR VENT, WHICH DRAINS INTO CAP

St. Louis, Mo. ARTHUR J. FOLEY.

Woes of a Hotel Engineer

ARRIVING ON the job at seven in the morning, the average hotel engineer has just about time to change his clothes when the phone rings and he gets a call to go to a guest's room to repair a light. Of course, his informant doesn't say that it is a table lamp, so, concluding that it is a ceiling lamp, he gets the stepladder and goes up on the elevator. Then, as he gets down to the engine room again, after giving the stepladder a nice ride, he gets a call to go to a room way up on the top floor of the hotel to fix a leaky shower bath, which he finds has been turned off by some would-be mechanic. He is then lucky to get time to light his pipe and have a smoke.

While he is cogitating on the follies of life in general, the fireman arrives on the scene with the news that the feed pump has refused to function. When he opens up the water end, he finds the whole "works" off the rod. After a time he gets the pump working again. Then, just as he starts up the steps to the engine room, he hears a swi-i-i-sh and looking around he discovers that the fireman has

closed both feed valves and that the gasket on the pump cover has blown out.

Perhaps an hour later, standing on the engine room balcony, he will see the fireman open the fire-door and put in a lump of coal so big that he has to drive it in with the coal hammer. This same lump, broken up properly, would fire the whole furnace with some left over. Again, he will see the fireman fire over the entire grate of a hand-fired stoker. After relieving himself of his feelings to the fireman, he again gets his pipe going and just gets nicely busy with the machinery when the dishwasher comes galloping in with the welcome information that his sink is plugged up. So the engineer goes up and, on opening the trap, takes out enough junk to stock a junk-man for 40 yr.

This same engineer will then start wondering what sort of a consulting or designing engineer laid out the hotel plant. In order to get to the elevator machinery, the engineer must take his own chance and go down under one of the cars. Also, when working over the boiler feed pumps, he has to stand almost on his head because these pumps are in a narrow alley, with the necessary piping and valves cluttered around the pumps so close that a man working on them burns his hands and arms several times a day. The engineer who has put in all his time in a factory power plant can certainly learn a lot about economy of space by working in a hotel. It is a common thing to think that marine plants consist of a lot of machinery in a small space, but the marine engineer can take a few lessons on economy of space from the hotel engineer.

Rochester, N. Y. R. G. Summers.

Comments on Factory Heating

In heating factory buildings, the nature of the product made has much to do with the ease with which the various rooms can be kept comfortable. Where we have charge of the heating, there are hundreds of pounds of small pieces of steel in process of manufacture into tools. At times this is a serious handicap in heating, at other times an advantage, especially where the shop works only in daytime, on account of the impossibility of raising the temperature of this mass of metal except by long continued application of heat. This makes it hard to keep the rooms warm in a sudden cold snap, but during a long period of cold, when the heat is kept on day and night and the masses of metal acquire the temperature of the room, the problem is easy.

Radiation is usually based on zero temperature outside and 70 deg. inside, but zero weather with no wind blowing is not a bad condition for heating, especially if there has been a snowfall. The snow has the effect of making the buildings tighter. It's a cold driving wind that worries us most.

In one-story buildings, the character of the roof has much to do with the ability to heat them properly. The worst type of roof we have had experience with is slate laid on sheathing. On such a roof, the planks shrink, leaving narrow cracks and, as the slates do not lie close, a driving wind will nullify all efforts at maintaining a proper temperature. Buildings with tar felt roofing are much easier to handle.

Newer buildings are equipped with cast-iron wall radiators which take up less room than coils, look better and if necessary can be extended to get more radiation in a room. The old buildings have wall coils; these do not look well and take up a lot of room, especially where there are pilasters on the inside walls.

With a plain gravity system long coils should have a vent at least equal to a full ¼-in. pipe opening. It is a fault of this type of heater that all the pipes may not heat up.

As a usual thing, it is much easier to heat rooms where there is running machinery, as the air is circulated by the motion of the machines.

Engineers in charge of the heating usually have few friends in winter. If they try to economize on coal, the workers, especially the female portion, don't love them and if they burn too much coal, the boss doesn't, so they catch it both ways. We believe in forced-circulation, hot water heating for this class of work and if we should ever rebuild our heating system, we would try to use it.

Anderson, Ind. J. O. Benefiel.

Care Needed in Using Blowoff Valve

Looking backward, after more than 20 yr. spent in power plant operation, I seem to see things that stand out like milestones along the way. One of these milestones is a blowoff valve. At the time, I was firing a battery of three return tubular boilers, in what today would be considered a small plant, ,furnishing light and power for a couple of country towns. In those days, when the various factories stopped at noon, it was customary to shut off the engine. As the load held right up to whistle time, I had to pump considerable water into the boilers when the engine was stopped to keep them from blowing off. That meant blowing down before starting up again at 1 o'clock.

One noon I had the blowoff valve of one boiler open and was watching the water settle in the glass, when a truck driver, who had dumped a load of hard coal screening in the yard, came rushing in with a bill for me to sign. He handed me a pencil with the bill, and for the moment my mind was taken away from the most important thing in the power plant—an open blowoff valve. When I handed him back the bill and pencil, he further distracted my attention from the job by mentioning a play-out some of the boys had been having with an old fire hand-tub.

When I next looked at the water glass, the water was out of sight! I raced into the alley and grabbed the wheel of the blowoff valve. Ye gods! It seemed as if the stem of that valve had twice the number of threads it usually had. At last, however, it seated. I went to the water column, opened wide the blow and then, closing it quickly, I jumped back where I could get a good view of the glass. By closing the valve quickly, I created a surge in the water column and I realized that if the water was not too low in the boiler, it would show in the glass.

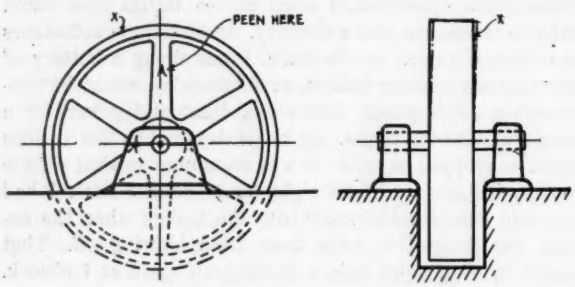
Just then the guardian angel who looks after engineers and fool firemen, must have used his influence, for I got a glimmer of water in the glass. It didn't take me long to get some more! You can readily believe that that foolish blunder, due entirely to carelessness, was never made the second time by me. The anguish of mind that I endured for a few moments is hard to describe, but so great was the impression made and so lasting its effect in the years that followed, that if Gabriel himself had appeared at the boiler room door while a blowoff valve was open, he would have tooted his horn in vain, as far as I was concerned.

Brockton, Mass. Frankland Cheney.

Peening of Arm Makes Wheel Run True

ANSWERING O. W. N.'s question in the Dec. 15 issue on making a flywheel run true, I suggest that, if the wheel fits the shaft and if the wobble was caused by the springing of the wheel while in the lathe or boring mill, it may be trued up by peening one of the arms with a ball-peen machinist's hammer.

To do this, first put the wheel in motion and mark the high spot by holding a piece of chalk so that it will just touch the point of greatest variation as the wheel revolves as shown at x on the sketch. Then stop the wheel and,



WHEEL IS TRUED BY PEENING AT A

on the arm nearest the chalk mark and on the side of the arm adjacent to the mark, as shown at A, give the metal a good peening, using a quick, sharp blow. This stretches the metal on one side only of the arm and causes a displacement of the metal in the rim near it. If the wheel is not more than ¼ in. out of true, it may be made to run almost perfectly by this method.

It is possible that in throwing the metal of the rim back by peening as described above, a slight eccentricity will be caused in the other direction; that is, looking at the rim in a line parallel to the shaft. Although this will in most cases be slight, the only way to remove it will be to rig some sort of rest for a lathe tool and to take a light cut across the face of the wheel.

I would advise anyone who uses the peening process to true up a wheel to rotate the wheel and use the chalk frequently to check up on the progress of the work. Engineers not familiar with this method will be surprised at the small amount of peening needed.

Chicago, Ill. D. E. BADGLEY.

High CO_2 Does Not Always Give Efficiency

HOW MUCH CO_2 should I get for best efficiency when operating a 264-hp. water tube boiler, with underfeed stoker, at ratings of from 100 to 200 hp.? I get 17 per cent CO_2 at all times with the boiler operating at 400 hp. but when running below normal rating, it is necessary to close the dampers and to admit enough excess air to prevent burning the grates. This reduces the CO_2 to about 12 per cent. P. C. F.

A. We believe that your value of 12 per cent CO_2, obtained under the low rating conditions you describe, is not far from correct. If an accurate flue gas analysis showed not more than 0.1 or 0.2 per cent CO along with this 12 per cent CO_2, we should say that the efficiency was excellent.

In connection with the value of 17 per cent CO_2 obtained when operating at 400 hp., it seems appropriate to point out that the CO_2 reading alone does not give an accurate indication of the efficiency of combustion. Such a figure is not unreasonable, but it should be remembered that as the percentage of CO_2 in the flue gas increases, there is also a tendency for the CO to increase, the thermal gain due to the minimum of excess air, as indicated by the high CO_2 being more than offset by the loss due to imcomplete combustion. Authorities on boiler operation agree that when a high CO_2 reading is found, it is well to determine also the amount of CO and free O, before a definite statement can be made concerning conditions.

Ordinary CO_2 recorders will not do this; the Orsat apparatus must be used as a check, unless you also have a CO meter. The presence of CO in itself is not serious, as it never causes losses of over 1 per cent, but it is usually accompanied by higher losses due to unconsumed hydrogen and hydro-carbons. In short, a high CO_2 content in the flue gas is not good unless there is an almost entire absence of CO, and not over 6 per cent free O.

For example, a certain test showed that, with a 10 per cent deficit in air supply, the CO_2 was as high as 18.7 per cent, but the CO was 4.5 per cent with no free O in the flue gas, giving a loss due to the CO of over 2000 B.t.u. per lb. of coal. On the other hand, with 25 per cent excess air, the CO_2 was 16.7 per cent, the CO practically zero with 4.2 per cent of free O, therefore no loss due to CO.

Whether you have enough excess air or not when operating at 400 hp. and obtaining 17 per cent CO_2, we cannot tell, of course. It may be that at this higher rating, your percentage of excess air is lower and in just the right proportion to the thickness of the fuel bed, that combustion is complete and that there is no CO loss. In such a case, your conditions would be good. The point we wish to make, however, is that the high CO_2 reading alone does not necessarily indicate good conditions, and that the CO_2 reading should be accompanied by readings of CO and O to get the best check on what the boiler is doing.

The drop in CO_2 to 12 per cent when running at 100 hp. is apparently caused by the fact that, under these conditions, the percentage of excess air is increased. Your statement that, when you close the stack damper, you must admit excess air to prevent burning of the grates at this low rating, seems to bear out this opinion. As the percentage of excess air increases, the percentage of CO_2 decreases, because the volume of CO_2 formed from the com-

bustion of carbon is the same as the volume of oxygen used. Therefore, the CO_2 per pound of carbon burned should be in the same proportion to the resulting flue gas as the oxygen is to the air supplied.

Theoretically, this is 20.9 per cent, the highest possible amount of CO_2 you can get. Now if 50 per cent excess air is supplied, then the 1.5 volumes of gas resulting contain 0.209 volumes of CO_2 or $0.209 \div 1.5 = 0.139$ or 13.9 per cent of CO_2. If 100 per cent excess air is supplied, the CO_2 in the flue gas is $0.209 \div (1.0 + 1.0) = 0.1045$ or 10.45 per cent. In general, the excess air required for good combustion is between 25 and 40 per cent. Forty per cent excess air corresponds theoretically to a value of 14.9 per cent CO_2.

Figuring Piston Diameter for a Given Cylinder

WE WISH to install new bull rings on our 24 by 42-in. hoisting engines. These rings will be 6 in. across the face with a snap ring at each end. How much smaller should the bull ring be than the cylinder bore? M. A. J.

A. In regard to the placing of a new bull ring on the piston of one of your hoisting engines, the following information is given in Kent's Mechanical Engineers' Handbook. "The clearance between cylinder and piston should be 0.001 in. per in. of diameter up to 20 in. cylinder diameter. Above cylinder diameters of 20 in., the clearance should be 0.0005 in. for each additional inch of diameter." Since the bull ring forms the outside of the piston, the clearance can be figured by this method. The snap rings at each end will, of course, be fitted to the bull ring so that they will bear against the cylinder walls when running with a pressure of from 3 to 4 lb. per sq. in.

By the above method, the clearance would evidently be:

$$24 - (20 \times 0.001) - (4 \times 0.0005)$$

which equals 24 — 0.022 in.

Amount of Condenser Water Is Found from Heat Balance

HOW MUCH condensing water is required to condense the exhaust from a 400-hp. cross-compound engine, exhausting at 26 in. of vacuum into a barometric condenser? The condensing water has a temperature of 80 deg. F. while that of the discharge in the condenser pit is 130 deg. F. The water rate of the engine is about 28 lb. per hp.-hr. The manufacturer says that 300 gal. per min. is enough to condense this exhaust but we find that 350 gal. per min. is not enough. There are no air leaks to speak of and the air pump is in good condition. A. L. S.

A. To determine the amount of circulating water required to condense the exhaust, it is necessary to make up a simple heat balance between the amount of heat supplied in the exhaust and that absorbed in the circulating water.

If we assume, as you have indicated, that the water rate of this engine is 28 lb. per hp-hr., then the total weight of steam to be condensed, with the engine running at capacity, is obviously $28 \times 400 = 11{,}200$ lb. per hr. This steam is condensed under a vacuum of 26 in. of mercury, at which pressure the total heat of steam is 1114.7 B.t.u. per lb. The temperature of steam at 4 in. of mercury, absolute pressure, is approximately 126 deg. F. It is unlikely that you would be able to attain this degree of vacuum when the discharge temperature of your circulating water is 130 deg. F. It is more likely that with the circulating water temperature you have mentioned the vacuum would be nearer 25½ in., at which the total heat is 1123 B.t.u. per lb. The temperature of the condensate will obviously be 130 deg., so that the heat given up by the steam in being condensed will amount to 1123 minus 130 plus $32 = 1025$ B.t.u. per lb. or $1025 \times 11{,}200 =$ approximately 11,500,000 B.t.u. per hr.

As the cooling water is heated from 80 to 130 deg., or through a range of 50 deg., the heat absorbed will amount to 50 B.t.u. per lb. of water circulated. To condense 11,200 lb. of steam per hr. will require $11{,}500{,}000 \div 50 = 230{,}000$ lb. per hr., or 3930 lb per min., which is equivalent to about 460 gal. per min.

Obviously, your circulating water requirements amount to $230{,}000 \div 11{,}200 = 20.5$ lb. per lb. of steam condensed. This figure is not excessive, according to the usual practice in this matter.

Oil Measurements Corrected for Standard Temperature

FUEL OIL for our boiler house is billed to us by the oil company in cars of 10,101 gal. each. We run this into a tank that is divided in the middle; the height of the oil is measured by a rod marked 391.4 gal. for each inch of rise or fall. When a car is emptied into one-half of the tank, the rise is 29.5 in., while a similar car emptied into the other half gives a rise of only 26.5 in. These tanks are heated to 140 deg. all the time. Does the difference in temperature between the oil as we measure it and the temperature the oil company uses cause this discrepancy? What temperature does the oil company use? How much does oil expand for 1 deg. rise in temperature? M. W. C.

A. From the information that you have given in regard to the filling of this tank, it is evident that it is not calibrated correctly. Fuel oil expands 0.0004 of its volume for a rise in temperature of 1 deg. F. On that account, a standard temperature must be agreed upon in order to make oil measurements correctly. The usual practice among oil companies is to reduce all measured volumes of fuel oil to the corresponding volume at 60 deg. F. In order to do this the following formula is used:

$$V_{60} = V_t \div (1 + [(T - 60) \times 0.0004])$$

in which V_{60} is the volume at 60 deg. and V_t is the measured volume at the measured temperature of the oil. These volumes are both expressed in barrels, cubic feet or pounds, as the case may be. T is the measured temperature of the oil in deg. F.

Let us assume for a moment that your calibration is correct. Then, when the rise is 29.5 in., $V_{60} = (391.4 \times 29.5) \div 1.032$, the difference between the measured temperature and the standard temperature being 80 deg. This gives a volume of 11,170 gal. at 60 deg., which is greater than the capacity of the car as billed. In the other case where the rise is 26.5 in., the quantity, reduced to 60 deg. by the same formula, is 9660 gal., which is less than the amount in the car as billed. The total of the two cars as shown by these figures, corrected for temperature, is 20,830 gal. The total as billed is 20,200 gal. a difference of about 3 per cent.

It is evident from these calculations that your tank should be recalibrated. The use of an oil meter would probably enable you to get a much better check on the quantity of oil than the method you are now using.

EDITORIAL COMMENT

Forestalling Obsolescence

As an engineer compares recently designed power plants with those of even 10 yr. ago he is, in most cases, impressed with the changes which have taken place in the fundamental conditions which are maintained.

During the past 10 yr. there has been a decided change in the general practice of furnace design resulting in higher temperatures, a greater percentage of CO_2 in the flue gas and better combustion in general. Steam pressures in common use have increased and the temperature of superheat has gone to the limit established by the strength of the materials used. More nearly perfect vacuums are maintained, generator voltages have gone up, ventilating and cooling systems have changed, relative space occupied by the steam boilers and the turbine generators has changed greatly and many other changes in details of construction and operation could be noted.

These changes in general practice have in some cases been foreseen and we have in the Joliet plant of the Public Service Co. of Northern Ill. an instance where the extension described in this issue varies but little from the original design of 7 yr. ago. This plant was an experiment in many respects at the time the first units were put into operation, today, however, we find it represents the best of modern practice. By this foresight of the engineers who designed the plant, its life has unquestionably been lengthened as obsolescence has been the determining factor in the usefulness of most plants which have been discarded during the past 20 yr.

Valuable Data Obtained by Follow-up of New Equipment

From time to time in these columns we have discussed the point of view the industrial plant engineer should take when approaching the management with requests for new equipment. Assuming, however, that he has convinced the management that the proper selection of certain new machinery will cut the power cost and that his request has been granted, there devolves upon him yet another responsibility after the equipment is in operation in the plant. That is the responsibility of making at least an attempt to find out whether or not the new apparatus is doing what it is supposed to do.

In altogether too many cases, the plant engineer neglects here a splendid opportunity to add to his professional reputation in an entirely legitimate way, as well as to cooperate with the various manufacturers of power plant equipment. In case the new equipment is not doing everything that was expected of it, certainly everyone concerned in the transaction ought to know why. If the equipment is doing what it was supposed to do—namely, cutting power costs—the fact reflects credit on the engineer's skill and judgment, it shows that the management was justified in trusting that skill and judgment and it affords the manufacturer of the equipment definite, incontrovertible evidence that his product gets the results he claims for it.

To get such information, even in an approximate form, seems to be one of the most difficult things in the whole field of engineering practice. Test codes and various methods of procedure for determining the performance of equipment have been worked out by the national engineering societies, but they cover in most cases only the larger prime movers. In a few cases manufacturers of engineering material have attempted to make such determinations, but they encounter so frequently an apathetic and uninterested attitude towards this proposal on the part of the management that they can accomplish little.

Possibly the lack of adequate records, so noticeable in the average industrial plant, has something to do with this condition.

Careful compilation of such operating records of the engineer in charge, followed by a tactful and unbiased presentation of the facts in the case to both management and equipment manufacturer, can do much to arouse interest in the importance of following up the operation of new equipment after it is installed. The engineer can thus obtain information of real engineering value and at the same time demonstrate to the management that in asking for new equipment he is not simply riding a hobby, but is sincerely endeavoring to improve his work.

Bringing the Foundation Out of the Ground

No longer is a wad of cement formed in a hole in the ground considered satisfactory as a foundation for machinery. Today the foundation for any main piece of equipment in the power plant is carefully designed and constructed to suit its particular purpose. As equipment has changed in design and arrangement so have the requirements of foundations changed.

Reciprocating machinery required considerable mass to prevent vibration but, as machine design became better understood, the vibration due to reciprocating parts has been greatly reduced and the need for weight has diminished. With the advent of reinforced concrete and the steam turbine, it became possible to make use of considerable of the space, which was formerly occupied by the foundation, for auxiliary equipment. Now the design of a foundation is a real engineering problem involving a consideration not only of weight but of proper distribution of strength and the most convenient arrangement of piping and auxiliaries. The bearing quality of the soil and the tie-in with the rest of the building must also be considered, if a satisfactory foundation is to be secured.

Taking up the special problems involved in the design of foundations for steam turbines, Walter Slader outlines in this issue the requirements for satisfactory foundations and their construction. Bringing the foundation up out of the ground and providing recesses, hallways and tunnels in and through it has been an interesting engineering evolution resulting in more economical arrangement of equipment and greater convenience to operators.

Self-Criticism

One of the most difficult problems for any individual is that of impartially criticizing his own work. It seems to be a characteristic of most men to think that their way is the best and that no improvement can be made upon it.

In engineering as in all other professions it is a comparatively simple matter to criticize the work of others, in fact much of the progress made in any endeavor is based upon a critical analysis of what others have done along the same line. It seems, however, to be less easy for some individuals to benefit by their own experience. It is not meant by this that they will make the same mistake over and over again but rather that their experience does not become accumulative, that they do not apply principles and that they have not learned to criticize their own work.

Applying this in a personal way we may consider the manner in which many men, power plant operators included, handle their income. They size up the living conditions of some of their neighbors and come to the abrupt conclusion that their income is inadequate for their needs. They reach this conclusion of course without having access to the methods of expenditure employed by their neighbors and they will not admit that their own methods of expenditure are haphazard and governed only by their fancies.

This same characteristic displays itself in the operation of a plant. The operator may have awakened to the fact that 60 per cent boiler efficiency was far too low, he may have raised it to 65 per cent, but there he stops and rests on his oars, saying, "Well that is the best that can be done with this coal," or something to that effect.

That attitude is not productive of the best results, it would be far better for one to take the stand that so far so good but the job can be done better. That puts the job squarely up to the individual, he must criticize his own work, he must get better results regardless of what the other fellow is doing.

When this analysis is first begun, the greatest handicap encountered is often that of a lack of records and statistics. Mr. Hoover has said that, "It is a truism to say that no individual business enterprise could succeed or be conducted without waste if it does not know accurately its stocks, the volume of output or sales, the rate of stock turnover, or its orders, or the prices, assets and liabilities and the relation of these to previous periods."

If this is true of big business it must be equally true of the component parts which go to make up big business. It resolves itself into progress being made through the analysis and impartial criticism of first the ways of the individual, which must oftentimes be made by himself, then that of the group and finally of the whole.

Off Duty

Some time ago a noted chemist was approached by his young nephew, who had recently been graduated from college with the degree of bachelor of science in chemical engineering, with a request that he aid him in securing a position.

"Very well," said the chemist, "I shall be glad to help you, but first I would like to know what you have done yourself. Have you tried any of the concerns around here?"

"O, yes," answered the young graduate. "I have tried a number of firms in the vicinity but there are no openings anywhere."

"Are you certain about that?" asked the uncle. "It seems to me that only last week the large paint and varnish company on the other side of town advertised for men. Have you tried there?"

"Of course I have, uncle," replied the nephew impatiently, "but they don't want chemical engineers there.

"O, they don't, eh? Well, my boy, it is certainly fortunate for you that they don't for if they did you would not have much of a chance to get a position with them. Go get a job with them, and after you have learned all there is to know about the paint and varnish game, then it will be time enough to talk chemical engineering."

Whether the young man took his uncle's advice in good faith and acted upon his suggestion or whether he is still laboring under the hallucination that he is a dyed in the wool chemical engineer, does not particularly concern us, but in our opinion the uncle's advice contains much sound logic.

Science and engineering hold alluring promises to the young men of today but they do not materialize without the expenditure of considerable effort.

In viewing one of the large turbo generators of our modern power station for instance we realize the work connected with its design, construction and installation, and we do not hesitate to express our admiration of it. What many of us fail to think about, however, is the work, the long years of effort of various men who labored in the development of the machine but yet had no idea of the machine itself. These men, Faraday, Watt and before them Hero and Branca, the men to whom the idea of the steam turbine first came, had no thought of developing a turbo-generator, and they lived their lives without ever seeing one, but their efforts contributed more perhaps to the finished machine as we know it today, than that of the expert designers in the engineering departments of the great manufacturing concerns that make them. They were the pioneers who first blazed the trail and to them belongs much of the glory.

The frontiers of our country have gradually been pushed further and further back until today the frontier as we once knew it, has vanished. The new frontiersman are the men of science—the men of the lens and meter, of the balance and the crucible, of the magnet and the spectrum, of the syllogism, and the equation. They are no less frontiersmen than this republic's early pioneers of the axe, the plow, the rifle and the saddle. Day after day, these new pioneers—frontiersmen even in the midst of cities—are out in search of bacteria, which are to them what the wild beasts or savages were to the early settlers. Night after night they venture forth over the universe's quadrillions of miles, hunters of the skies to bring back fresh stellar truths to the earth.

The young man of today wishing to immortalize himself in the name of science has plenty of opportunity—there are many roads but all of them are hard and equally difficult to travel. But to the man who really has the interests of science at heart, this means nothing. He willingly enters upon the most difficult one and gives his best to reach the end. He may not always reach the end but in any case he will have the satisfaction of knowing that some day perhaps somebody will take up the journey where he left off and that in this way his labors will not have been in vain.

Research Principal Topic at A.S.H.V.E. Meeting

THIRTY-FIRST ANNUAL CONVENTION OF HEATING AND VENTILATING ENGINEERS BRINGS FORTH RECENT ACHIEVEMENTS IN HEATING AND VENTILATING

AN UNUSUAL amount of interest in providing adequate funds for the maintenance of a research laboratory was displayed by the members of the American Society of Heating and Ventilating Engineers attending the convention in Boston, Mass., January 28 to 30.

This Society, in spite of the fact that its membership is barely 2000, has for some years past maintained a laboratory for conducting research in the art of heating and ventilating in co-operation with the U. S. Bureau of Mines at Pittsburgh. It is, in fact, the only society of its kind which has maintained such a laboratory. Under the direction of F. Paul Anderson, director of the Laboratory, who is also Dean of Engineering at the University of Kentucky much excellent work has been done but for some time past it has been evident that in order that the research work might continue, further financial support would have to be provided since the normal dues of the members have been insufficient to carry on the work in a suitable manner. One of the most important problems confronting the recent convention, therefore, was to work out and put into effect some plan whereby such financial support could be secured.

The plan finally arrived at, provides a permanent income of over $18,000 a year to be spent only for the maintenance of the research laboratory. In addition to this sum which is to be secured by additional dues, a considerable sum of money for research work was pledged by various organizations who are interested in the work the society is doing.

The convention was officially opened in Boston with a professional session at the Copley Plaza Hotel, Wednesday morning, January 28, although a special business session had been held at the Engineering Societies Bldg. in New York City on the previous day.

The first technical paper presented at this session was one entitled "Heating and Ventilating the Modern Steam Station," by David S. Boyden and A. B. Williams. This paper was actually a study of the methods employed to fulfill the heating and ventilating requirements at the new Weymouth station of the Edison Electric Illuminating Co. of Boston. This marks a new phase in power plant design and construction. Heretofore, little consideration has been given to the heating requirements of the power plant as the natural radiation from the power producing apparatus was usually sufficient to take care of any heating requirements. In the modern station, however, the heat available for heating the building by radiation from the power equipment is comparatively small in quantity and it is necessary to supplement this heat by artificial heating during the severe winter months. In summer it is necessary to provide ventilation to maintain the plant at a comfortable point.

Normally the steam for heating the Weymouth Station is furnished by the exhaust from a small steam turbine driven direct current generator so arranged with respect to other auxiliary equipment that it can be operated at any load desired. The steam exhausted from this turbine can therefore be made to fulfill exactly the requirements of the steam heating system. In order to supplement this source of supply, a special reducing valve is provided which reduces steam pressure from 350 to 10 lb., the pressure used in the heating system. This valve is operated in conjunction with a desuperheater.

This paper, naturally created a considerable amount of discussion, particularly with regard to the design of a reducing valve capable of taking care of so large a pressure drop in a single valve. In this discussion it was brought out that the ideas incorporated in the construction of this valve were derived from the principles of steam turbine practice, that is, a stream line passage or nozzle is one of its basic features. It is therefore different from the usual type of reducing valve, and as it is not a balanced valve, it is entirely free from chattering. With regard to the desuperheater used in connection with this valve, there was some discussion as to whether the spray type employed, was the most satisfactory arrangement. W. H. Carrier stated his experience with the induction method of desuperheating and suggested that it might have been employed to good advantage in this case. This method, Mr. Norris who had been instrumental in the design of the desuperheater said, had not been considered.

Another paper of considerable interest was that presented by F. E. Giesecke upon the Effect of Temperature upon the Friction of Water in Pipes. It is important, said Professor Giesecke, in making calculations relating to hot water heating, to know how the friction varies with the temperature of the water. The author of the paper refered briefly to the work of other investigators along this line, particularly that of Professor Blasius and Dr. Brabbee in Germany and then described his own experiments which were conducted with commercial black pipe covering a range of diameters from ½ to 3 in., of velocity from 0.05 to 3 ft. per sec., and of temperatures from 64 to 72 deg. F.

In this paper it was brought out that the effect of roughness of pipe is much greater in the case of small diameter pipes than in pipes of large diameters. This of course is to be expected. Professor Giesecke developed formulas for determining the friction at various tempera-

tures and presented a number of charts showing the relations between pipe friction and the Reynold's number.

Discussion of this paper took up the application of Professor Giesecke's results to commercial practice. Mr. Hart questioned the advisability of publishing exact data of this kind in the Code of Minimum Requirements for the Heating and Ventilation of Buildings which the society is attempting to formulate on the basis that it does not take into consideration suitable factors of safety. It is impossible, he pointed out, to predict or plan with any degree of certainty the exact number of elbows in a certain heating system, and to guard against an unlooked for amount of friction due to this fact, he selected pipe sizes somewhat larger than perhaps necessary. Mr. Bolder of Warren, O., also stated his opinion that any code drawn up must apply to practical work.

In replying to these remarks, Professor Giesecke pointed out that the matter of practical application of this particular research hinged, not upon the accuracy of the methods or the formulas but upon the shortcomings of commercial planning. "We can't tell anybody how to make it easy to determine the number of elbows in a heating system but we can show you how to calculate the friction in the system if you know the number of elbows and other required constants." The data of authorities can be accepted provided it is stated in the code that its application in commercial work depends upon the accuracy with which it is applied.

Friday morning's session was marked by the presentation of three papers all on the general subject of heating. The first paper, "Basing Warm Air Heating Selections on Climatological Conditions and Heater Performance Curves," by V. S. Day, was presented by Prof. Willard of the University of Illinois. This paper stated briefly the requirements of air heaters with regard to yearly and daily temperature variations and also of standby capacities. A large standby or reserve capacity is needed during periods of rapidly decreasing outdoor temperatures or during early morning firing. This fact is often overlooked in the design of an air heating plant.

The other two papers of this session were "Some Facts about Enclosed Radiation," by R. V. Frost, and "Characteristics of an Air Tube Heater," presented by L. R. G. Bousquet of the U. S. Cartridge Co. The first paper brought out the interesting fact that enclosures can be designed for radiators that will cause the radiator to emit more heat than can be obtained from the same radiators when bare. The second paper described in detail a new type of copper tube heater, and the methods used in determining its operating characteristics. This heater is built somewhat on the order of an automobile radiator and has an exceedingly large radiating surface for its size. A heater 16 by 12 in. across its face and only 6 in. deep, for instance, has a radiating surface of over 52 sq. ft. To heat air to the same temperature that is obtained in passing through the 6 in. of copper tube in this new radiator, in a cast iron radiator would require a bank of the latter about 30 inches deep. The friction losses, too, are lower with the copper tube radiator. With the cast iron type of radiator the friction loss varies as the square of the velocity while with the new copper tube heater it varies as the 1.82 power of the velocity.

Other papers on various related subjects such as the determination of dust in air, industrial applications of ozone, and electrostatic precipitation of dust were also presented at this convention. All of these papers were received with considerable interest and their presentation indicates excellent cooperation between the research department of the society and other interests. The society is particularly concerned with the physician's view of ventilation and heating in its effect upon human beings and through the splendid work by Dr. W. J. McConnell, surgeon at the U. S. Bureau of Mines, much valuable information is being collected. The studies upon the effect of temperature and humidity upon basal metabolism, and the establishment of comfort zones of temperature and humidity are worthy of particular mention. This work should be of great benefit in providing better health and working conditions in factories.

Outside of the purely technical sessions there were many other events to interest the visiting members and guests. A number of excellent inspection trips to various manufacturing plants in the vicinity as well as trips of historic interest in and around the city of Boston were highly enjoyed. Through the courtesy of Stone and Webster, Inc., and the Edison Electric Illuminating Co. of Boston, a special trip was made to the new Weymouth Power Station. Other trips were made to the B. F. Sturtevant Co. at Hyde Park and the U. S. Cartridge Co. at Lowell.

Among the social events, the outstanding feature of the convention was the dinner dance at the Copley Plaza, Thursday evening. This was well attended and enjoyed by everybody.

Election of officers for the ensuing year was held in New York on Monday before coming to Boston. Succeeding Homer Addams as president of the Society, S. E. Dibble was elected to fill the chair during 1925. William H. Driscoll was elected first vice-president, and F. Paul Anderson, second vice-president. Perry West, of Newark, N. J., and F. C. Houghten, of New York, were re-elected treasurer and secretary respectively. The members of the new council for the year are as follows: S. E. Dibble, chairman; F. C. Houghten, secretary; F. Paul Anderson, W. H. Carrier, J. A. Cutler, Wm. H. Driscoll, J. H. Walker, A. C. Willard, W. T. Jones, Homer Addams, W. E. Gillham, Thornton Lewis and Perry West.

Reorganization of Govt. Eng. Work Favored by A. E. C.

AT ITS assembly meeting in Washington, American Engineering Council voted in favor of endeavoring to secure such modification of government reorganization as will bring government engineering under the Department of the Interior; to work for national and local cooperation with Federal action in a study of reforestation, and active forestry work. It was decided to continue participation in the National Board of Jurisdictional Awards as the committee reported that in 5 yr. of effort the board has accomplished a valuable service of benefit to workmen, contractors, building owners and the public. It has been of value to those of the engineering profession connected with the design and construction of buildings and has helped to stabilize building conditions.

Opposition was expressed to further entry of government into business affairs including specifically active participation in extension of power supply by a comprehensive plan of water-power development, investigation of carrying out public works during periods of depression, (but

the council favored limiting of such work during active construction periods and extension during depressions), and creation of additional government agencies. Increase in traveling allowance from $5 to $7 a day was favored for engineers in government service and change of travel regulations to conform to established business practice.

Special study of safety on streets and highways was favored and appointment of an engineering committee for this purpose was approved. Opposition to wooden sleeping cars, higher salaries for federal judges and comprehensive study of reclamation problems were favored. The Federal Power Commission was endorsed, also appropriation of additional funds for its use.

A. W. Berresford of Niagara Falls, N. Y., representing the A. I. E. E. and Dexter Kimball of Cornell University, representing the A. S. M. E., were elected vice-presidents. Harrison E. Howe, Washington, D. C., was re-elected treasurer and Lawrence W. Wallace again chosen as executive secretary. The Engineers Club of Little Rock, Ark., was admitted to membership.

The next meeting of the Council will be held in Philadelphia in May.

Surface Air Cooler Made With Spiral Fins of Copper Ribbon

GENERATOR VENTILATION may be effected by the recirculation of the ventilating air of the turbine-generator back to the machine after it has been cooled by passing over the surface of a cooler using water as its cooling medium. The surface air cooler recently developed and manufactured by the General Electric Co. consists of one or more sections, each mounted in a structural steel frame supported by hollow cross struts. The frame and all fittings are sherardized. The fin wound tubes are contained within the frame and are held in place at either end by a tube sheet of Muntz metal and supported midway in length by a tube support. In order to make easy the replacement of an individual tube without disturbing any other, the tubes are expanded into the tube sheet on one end and into a brass plug on the other end. This plug has a straight thread for screwing it into the tube sheet and a shoulder to receive a fiber gasket which makes tight the joint between the plug and the tube sheet. The thread in the tube sheet for receiving the plug is just large enough to permit the withdrawal of the fin wound tube through the tube sheet.

ONE TUBE SHEET AND WATER BOX FLOAT TO CARE FOR EXPANSION AND CONTRACTION OF THE TUBES

By alternating the plugs, half in one tube sheet and half in the other, ample material is left in the tube sheet for strength. Expansion and contraction of the tubes are taken care of by allowing one tube sheet and its water box to float. This is accomplished by fastening the tube sheet to flexible bars forming part of the cooler frame. These steel bars are proportioned so that they will deflect with a small load.

Cast-iron water boxes are bolted, by means of studs and nuts, over the tube sheets. These boxes are provided with large inlet and outlet connections to reduce turbulence tending to affect the distribution of water through the tubes. Partitions are cast integral with the boxes so as to form any number of water passes that may be desired. In order to facilitate the cleaning of the interior of the tube surfaces, a separate cover is provided and the water connections brought out at the top and bottom so that the cover may be removed without disturbing the piping system.

Tubes may be either ⅝-in. or 1-in. outside diameter and of either Muntz or Admiralty metal as may be required. The principal service advantage of the larger diameter tube is that there is less chance of fouling where somewhat contaminated circulating water is used. To offset this advantage, the ⅝-in. tube has a higher heat transfer value than that obtained with the 1-in. tube. To increase their external radiating surface, the tubes are wound with spiral fins made from a continuous length of copper ribbon. These fins are shouldered and soldered to the tubes, so that the joint presents no measurable drop in temperature or resistance to the flow of heat.

Resistance to the flow of air through the cooler is dependent on the air velocity and the depth of the cooler, the temperature of the air having only a slight effect on the drop in air pressure through the cooler. The loss of head or resistance to the flow of water is also a variable quantity and there is considerable latitude in regulating the total pressure drop.

One of the purposes of a surface cooler is to insure a clean generator. If the system is sufficiently tight so that there is practically no deposit on the generator, then the external cooling surface of the cooler should also be clean. If the generator surfaces become fouled and clogged, then the cooling system is defective. Should the coolers become dirty through any fault of design or operation they can be cleaned by submerging and boiling each section in a tank of water and washing soda. Should any oil vapor flow into the circulating system, it might condense only on the cooler and not on the generator.

Second Turbine at Long Beach Put in Operation

OPERATION of the second 35,000-kw. turbine generator at the new Long Beach station of the Southern California Edison Co. was started on Jan. 21, a year after the order for the 70,000-kw. equipment was placed with the General Electric Co. The first 35,000-kw. unit was placed in operation on Dec. 3. The second complete unit, requiring 13 cars and weighing a million pounds exclusive of blocking and crating, left Schenectady Nov. 26 and reached its destination at midnight of Dec. 8. One of the pieces, weighing 185,000 lb., was transported on a special flat car.

The boilers which supply steam to the turbines are designed for operation with either natural gas or oil as fuel. The construction of the new plant was rushed to meet the growing demands for power caused by the rapid industrial development of the Los Angeles Harbor district.

Dump Grate Units Cannot Be Dislodged

GRATES are not only used to support the fuel during combustion but also to assist in its efficient combustion and to permit easy cleaning and removal of ash. To support the fuel properly, the grate must have sufficient bearing area and must also be strongly built and to assist in efficient combustion, the air spaces must be ample in size and shaped so as to be self-cleaning. To permit simplified operation when cleaning and removing ash, the grate operating mechanism must be both positive and conveniently manipulated, for cleaning a fire is not pleasant work at best and it is likely to be shirked if too difficult, with resulting poor efficiency of combustion and waste of fuel. These points have been incorporated in the Neemes "Superior" dumping grate as manufactured by the Neemes Foundry, Inc., Troy, N. Y.

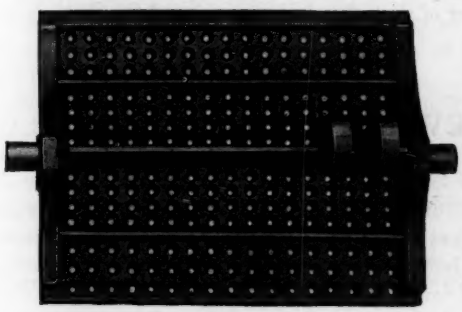


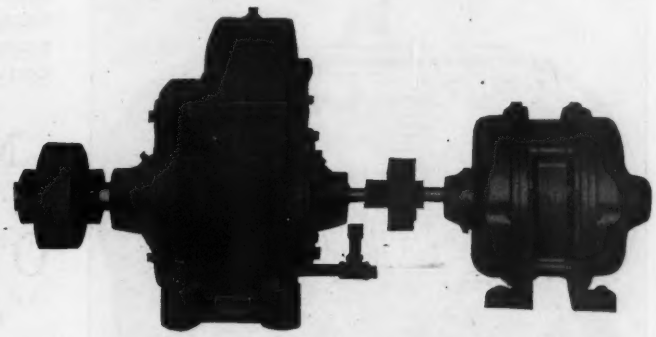
FIG. 1. AIR SPACES ARE WIDENED BELOW THE SURFACE TO PREVENT CLOGGING

FIG. 2. THIS GRATE CAN BE MADE TO REST ON THE USUAL BEARING BARS OR DEAD PLATE LIP

Size, number and shape of the air spaces in these grates depends upon the fuel to be burned. In all cases, the air spaces widen out, as shown in Fig. 1, below the surface of the grate so as to be self-cleaning, thus any ash passing the top of a slot or hole cannot clog it up but will immediately drop to the ashpit. Lugs which are cast on the dumping units for the attachment of the dumping mechanism are long and centered, providing extreme ease of operation and permitting dumping the fire with slight muscular effort. The arrangement of dumping sections is flexible in that the grate can be furnished so the front sections dump toward the rear and the rear sections dump toward the front, or vice versa, as desired. It is, however, most generally desired that all sections dump toward the front so as to make ash removal more convenient. In dumping the grate there is no danger of any units being forced up into the fire by the wedging of clinkers, as a patented lock box holds all units in place at all positions of the unit. When the grate has been returned to the normal operating position after dumping, there is an additional double positive lock to maintain it in the level position and prevent the ends of the dumping unit from working up into the fire with danger of burning off. Protection against warping and buckling is also assured by making the grate exceptionally deep, thus giving maximum cooling surface.

New Spur Gear Speed Transformer

MANY APPLICATIONS are claimed for a new "Industrial Type" Spur Gear Speed Transformer recently developed by the Hill Clutch Machine and Foundry Co., of Cleveland, O. This device, a view of which is shown in the accompanying illustration, consists of a nest of plain spur gears revolving in oil, changing the number of revolutions per minute of the input shaft to some other desired speed on the output shaft. The power transmitted is the same in both shafts. The gears all have 20 deg. involute form cut teeth.



VIEW OF HILL CLUTCH MACHINE & FOUNDRY CO. SPEED TRANSFORMER

A particular feature of this speed changer is the central housing located in the main frame. This construction permits of a transformer having both high and low speed shafts supported in double bronze bearings, insuring strength, rigidity and quiet operation. Provision is also made for ordinary thrust conditions.

The cap, as well as both ends, can be removed, thus providing ready accessibility. The oiling arrangement is continuous, a thorough splash system obtained by a metal disc on the high speed shaft automatically lubricates every gear and bearing in the case. The entire unit is enclosed and is dust proof and leak proof.

Both high and low speed shafts are in identical axial alinement. The action is positive and both shafts revolve in the same direction.

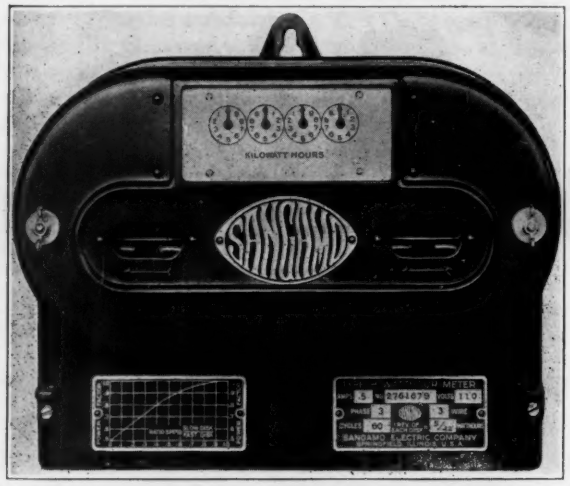
The "Industrial Type" speed transformer is made in seven sizes. Each size has a number which bears a fixed relation to the diameter of the low speed shaft. The number also indicates the horsepower the low speed is capable of safely transmitting at 100 r.p.m. It is the "short cut" from electric motor to machine or from shaft to shaft where speeds are widely different. It eliminates cumbersome speed changing devices, saves power losses, and being a closely coupled unit requires little space for installation.

Polyphase Watthour Meter Also Shows Power Factor

INCREASING INTEREST in voltampere measurement, and in power-factor analysis under operating conditions has resulted in the development of the Type H horizontal polyphase watthour meter by the Sangamo Electric Co., Springfield, Ill.

The meter shown in the accompanying illustration has two complete independent Sangamo Type H single-phase meter elements geared to a differential train that totalizes on a single register the algebraic sum of the energy measurements of the two meters.

By noting the number of revolutions made by each of the two disks during a definite time interval, the power-



SANGAMO TYPE H HORIZONTAL POLYPHASE METER

factor can be readily determined from a graph on the terminal box door. All that is necessary is to divide the number of revolutions made by the slower moving disk in a definite time interval by the number of revolutions made by the other disk in the same length of time.

The graph on the terminal box door enables the quotient thus obtained to be immediately converted into power-factor.

Electrically and mechanically the two elements are entirely independent and each may be calibrated exactly like a single-phase meter and adjusted without reference to the other, the operation taking less time and less equipment than is ordinarily required for calibrating polyphase meters. All constructional details, except the base, case and register, are identically the same as those used in Sangamo single-phase Type H meters for over ten years.

Stone & Webster to Manage Western United Corporation

THE WESTERN UNITED CORPORATION which supplies electric gas and railway service in 87 communities in Illinois including a portion of the Chicago suburbs and Aurora, Elgin, Elmhurst, La Grange, Joliet, Marion and Murphysboro, has signed a contract with Stone & Webster, Inc., of Boston, who are to furnish an executive management service to the group of subsidiary operating companies which are owned by the Western United Corp.

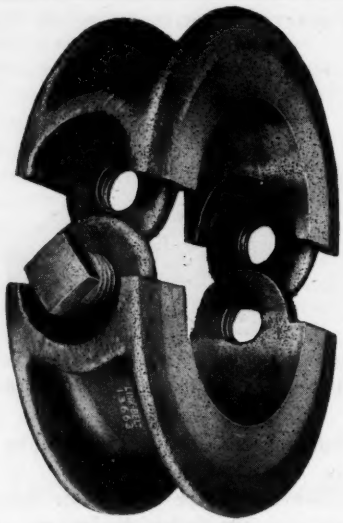
Consolidation of the companies of the Western United Corp. has been accomplished by its president, Ira C. Copley, and the organization which he has built up has been for many years an essential factor in the growth of the communities which it serves.

The Western United Corp. operates two main groups of companies; one including 63 of the cities and towns served lies in an area ninety miles long and forty wide, near Chicago, the other includes a large part of southern Illinois. In addition the companies own large natural gas wells, oil wells and coal mines. Electricity is supplied to communities which have a total population of 80,000, while the population receiving gas service numbers over 300,000.

Alfred F. Townsend, manager of the Eastern Texas Electric Co. of Beaumont and Port Arthur, Texas, which is one of the companies under Stone & Webster executive management, has been made vice-president and general manager of the operating companies of the Western United Corp.

New Safety Collar Made of Malleable Iron

ONE of the most recent developments in line shaft devices comes from the Link-Belt Co. of Indianapolis. It is a new safety collar and it is intended to maintain the



COLLAR IS SPLIT IN TWO PIECES TO AFFORD EASY ADJUSTMENT

proper alinement of such equipment as pulleys, shaft bearings and hangers.

The new design permits the collar to be split in two pieces, thus affording ready and economical installation or adjustment. This type of collar, however, is made also in the solid ring type, both types being machine finished. The material of which it is made possesses good wear and rust resisting qualities. This extends its sphere of usefulness to installations where the atmospheric conditions contribute to rust or excessive abrasiveness. The set screw, by which the collar is firmly affixed to the shaft, is flange protected.

Engineering Societies to Observe Oil and Gas Power Week

CO-OPERATING organizations have set the date for the first Oil and Gas Power Week as April 20-25, 1925. The week will be celebrated by technical meetings to be held in selected cities throughout the country, at least 25 in number. Industrial plants in the selected communities will be asked to co-operate. Topics to be studied during the week will be the use of the Diesel engines in central stations, industrial plants and on shipboard, methods of testing oil and gas engines, and problems in design, weight reduction, operating costs, etc.

Co-operating with the American Society of Mechanical Engineers in plans for the week are the following organizations: National Association of Stationary Engineers, American Society of Marine Engineers, American Chemical Society, American Society of Naval Engineers, National Safety Council, American Society of Agricultural Engineers, U. S. Chamber of Commerce, Society of Naval Architects and Marine Engineers, U. S. Bureau of Mines, and the U. S. Department of Commerce.

A general committee and an executive committee will be appointed by the above organizations to make and execute plans for the week. W. E. Bullock, assistant secretary of the A. S. M. E., has been appointed to act as corresponding secretary and inquiries should be addressed to him at 29 West 39th St., New York, N. Y.

Power Survey Along Snake River

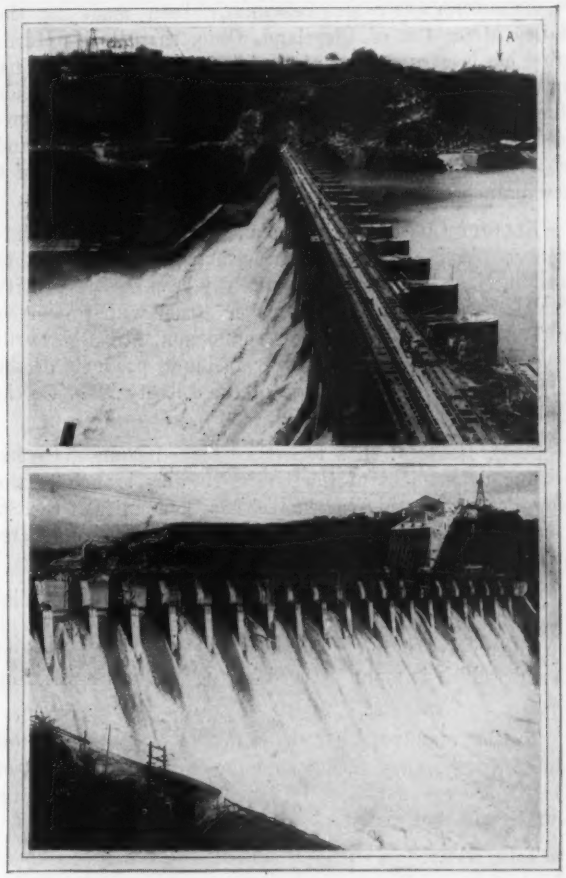
MAPS SHOWING the results of surveys made by engineers of the Department of the Interior to determine the water power available on Snake River, Idaho, have just been published by the Geological Survey. The work done included a survey of the bed and banks of the stream and the adjacent country from Lewiston, Idaho, to Huntington, Ore., a distance of 187 mi., as well as detailed surveys of five dam sites. In this distance the fall of the river is 1321 ft., which makes possible the development of more than a million horsepower. The work done included also a survey of the divide between Snake and Salmon Rivers, an area consisting of 30 sq. mi. The results of the work are shown on 17 maps.

In connection with this survey a study of the possible water-power sites on Snake River was made by W. G. Hoyt, who found 15 undeveloped power sites at which, with the present flow, 1,430,000 hp. can be developed for 50 per cent of the time and 861,000 hp. for 90 per cent of the time. With regulated flow and complete irrigation development 1,080,000 hp. can be developed for 50 per cent of the time and 750,000 hp. for 90 per cent of the time.

One of the projects considered includes a diversion dam on Salmon River, a tunnel to Snake River, and a dam 530 ft. high on Snake River. As this project would make possible the development at one plant of 910,000 hp. for 50 per cent of the time and 636,000 hp. for 90 per cent of the time, the site is one of the largest yet undeveloped in the country. Under a nation-wide superpower network that has been proposed and discussed by prominent engineers the energy made available at this site would be fed into a trunk line extending between Salt Lake City and Spokane, which would radiate power eastward to the Mississippi Valley and westward to the Pacific Coast. The only site already developed in this stretch of the river is a 12,400-hp. plant near Copperfield, Ore.

Hydroelectric Power Plant Just Completed in Japan

THE Oi hydroelectric power plant, 150 mi. from Tokyo, Japan, with a capacity of 42,700 kw., was recently completed. This power plant supplies electrical energy to Tokyo, which is 150 mi. to the north, and Osaka, which is 150 mi. to the south. Transmission is at 154,000 v.



DAM IMPOUNDING WATER USED TO GENERATE POWER FOR TOKYO AND OSAKA, JAPAN

Top—Looking down on the Tainter gate construction and tracks used for carrying concrete. Bottom—Lower side of dam with concrete mixing plant on the bank to the right.

Accompanying illustrations show the Oi dam just above the power plant. This dam is 190 ft. in height and 1200 ft. in length and contains 240,000 yd. of concrete. Plumb rock was used in the construction. Aggregate was obtained close to the dam which was crushed to the proper size in a crusher. The crusher and concrete mixing plant were built on the bank of the river at the dam site, the concrete being delivered by means of dump bottom cars traveling on rails supported by a superstructure as shown in the photos. There were also two steel cable-ways extending across the river which were used in handling material and equipment. This dam is built across the Kiso River and since its construction, floods have resulted in a flow of 23 ft. 8 in. over the crest of the dam without damage. This is about 170,000 sec. ft.

At the left of one of the accompanying photos can be seen the steel structure for the high tension switching

station and at the right below the arrow at "A" can be seen the intake which is approximately 70 ft. in height, giving a very low inlet velocity. Japanese cement meeting all United States specifications was used in the construction of dam, power house, etc.

There is a total head of 200 ft.

News Notes

ANNOUNCEMENT HAS RECENTLY been made by the Bailey Meter Co. of Cleveland, Ohio, that R. M. Hardgrove has been appointed research engineer, R. D. Junkins, formerly manager of the Boston office, has been made chief engineer, P. T. Reuter has been appointed to succeed Mr. Junkins as manager of the Boston office, and M. J. McWhorter has been appointed to take charge of a new branch office opened at Atlanta, Ga.

ELLIOTT Co., Pittsburgh, Pa., announces the appointment of A. L. Rider as district manager with offices in Boston, Mass. Mr. Rider has recently been associated with the Henry L. Doherty Co. in connection with properties in Todelo, Ohio. In his new connection, Mr. Rider will have charge of the sale of Kerr turbines, products of the Lagonda Mfg. Co. and those of the Liberty Mfg. Co. in the New England territory.

J. P. HILLMAN has recently resigned from the engineering department of the Hester-Bradley branch of the Kewanee Boiler and Warren Webster Companies of the St. Louis district and has become manager of the valve department of the Bayer Co.

ON JANUARY 1, the United Equipment Co. of Philadelphia, Pa., took over the entire sales service of the Victor Steam Jet Ash Conveyor of the United States and Canada which is manufactured by the Victor Engineering Co.

THE PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION Co. of Pittsburgh, Pa., has announced the appointment of the R. J. Crozier Co. of Philadelphia as its sales representative in that district.

THE BAKER DUNBAR Co. announces the appointment of Wolff & Co., Wrigley Bldg., Chicago, as territorial representatives for the sale of ash hoppers, grates and sluice ways.

Catalog Notes

IN THE NOTICE of the condensed catalog of mechanical stokers issued by the Stoker Manufacturers Association, which appeared in the issue of Power Plant Engineering for Dec. 1, the name of the Westinghouse Electric & Mfg. Co. was omitted from those whose apparatus is described in the condensed catalog. This was an oversight on the part of the staff of Power Plant Engineering, which we hasten to rectify and for which our apologies are due to the Westinghouse Electric & Mfg. Co.

BULLETIN NO. 1700 has recently been issued by the American Schaeffer & Budenberg Corp., Brooklyn, N. Y., discussing the Columbia Strip Chart Recorder which is intended for application where it is desirable to obtain a record of temperatures or pressures for an extended period of time and where the cycles of operation are of relatively short duration requiring a wide open record enabling detection and study of the slightest variations.

MARION MASTER GRATES are described in bulletin 209 just issued by the Marion Machine Foundry & Supply Co., Marion, Ind.

LAGONDA BOILER tube cleaners are described in bulletin T-4 recently issued by the Lagonda Mfg. Co. of Springfield, Ohio.

IN THE CIRCULAR entitled Nelson Black Line Gages, the J. E. Lonergan Co. of Philadelphia, Pa., announces that it has purchased that part of the Nelson Mfg. Co. devoted to the manufacture of steam pressure and hydraulic gages.

THE CONVEYORS CORP. of America has just issued a folder describing the American Mono Rail Cable Conveyor which can be used for handling coal from cars to bins, silos, bunkers or pile and can also be used in a power plant as well as the coal yard.

IN A 12-PAGE bulletin recently issued by the Bailey Meter Co. of Cleveland, Ohio, meters for coal and granular material are described. The bulletin is well illustrated to show how a number of plants are equipped to obtain test results from their boilers every day.

THE GRAVER CORP., East Chicago, Ind., has recently issued its bulletin No. 501 entitled "Pressure Type Water Filters." The bulletin describes the filtration methods and shows the construction of Graver filters and gives complete details of sizes and capacities available.

BULLETIN D-1 entitled "Feed Water Heaters" has just been issued by the Elliott Co., Pittsburgh, Pa. In this bulletin, the application of different types of heaters to various conditions and the advantages and disadvantages of various types are discussed.

O. E. FRANK Heating & Engineering Co., Buffalo, N. Y., has just issued bulletin No. 25 describing the company's line of heaters, coolers, condensers and exchangers. The bulletin includes tables of capacities and general dimensions and gives diagrams showing the proper pipe connections for the different kinds of equipment.

GRISCOM-RUSSELL instantaneous heaters for supplying hot water for boiler feed and other purposes are described in a leaflet just published by the Griscom-Russell Co., New York City. This leaflet outlines the applications, special advantages and construction specifications of the heater and includes a complete table of capacities, sizes and dimensions.

WET STEAM, its causes and mechanical purification is a subject upon which a great amount of investigation has been carried on by the Hagan Corp., Pittsburgh, Pa., in co-operation with the United States Bureau of Mines. The results of this work now have been made available in printed form by the Hagan Corp. This booklet was prepared by G. W. Smith, chemical engineer, and it is designated as technical paper No. 16-S.

A NEW 32-PAGE bulletin, bearing the number 47,495.1, has been issued by the General Electric Co. describing four improved types of oil circuit breakers. The bulletin is illustrated by photographs, tables and diagrams, and details covering construction, operation and characteristics, are fully covered. The circuit breaker types described are all for controlling and protecting circuits of large capacity. The capacities of these oil circuit breakers vary from 2000 amp. at 15,000 v. and 500 amp. at 35,000 v., to 4000 amp. at 7500 and 15,000 v., and 800 amp. at 35,000 v.